DOCUMENT RESUME

ED 431 292 EF 005 386

AUTHOR	Tawney, David
TITLE	Fume Cupboards in Schools. (Revision of Design Note 29). Building Bulletin 88.
INSTITUTION	Department for Education and Employment, London (England). Architects and Building Branch.
ISBN	ISBN-0-11-271027-1
PUB DATE	1998-00-00
NOTE	63p.
AVAILABLE FROM	HMSO Publications Centre, P.O. Box 276, London, SW8 5DT England; Tel: 0171-873-9090; Fax: 0171-873-8200 (14.95 British pounds).
PUB TYPE	Guides - Non-Classroom (055)
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	Biological Sciences; Chemistry; *Equipment Standards; Foreign Countries; *Laboratory Equipment; Safety; Secondary Education; *Secondary School Science; *Secondary Schools
IDENTIFIERS	England; *Fume Hoods; Gases

ABSTRACT

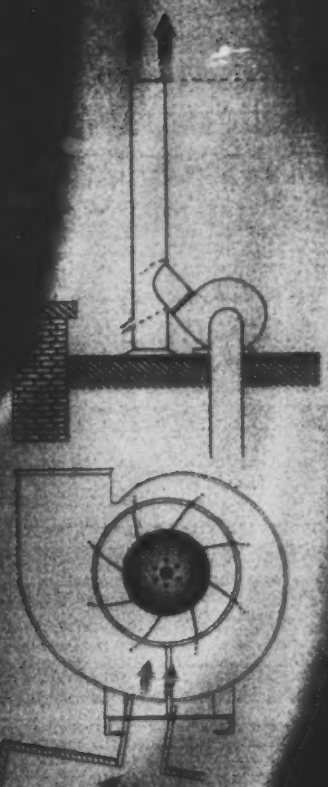
Regulations require hazardous gases in school science classrooms to be controlled, i.e., their levels in the air kept below the exposure limits, with fume cupboards being the most usual method. This document reviews the requirements for fume cupboards used in schools and colleges for teaching the sciences, mainly chemistry and biology, up to A-level GCE. It covers the level of provision that is desirable to meet curriculum needs and makes recommendations for good practice in the design, specification, and installation of fume cupboards and their related extraction systems. Also addressed is the commissioning and monitoring of fume cupboard systems and the repairing and upgrading of existing fume cupboards. Appendices include a description of how a fume cupboards works, the monitoring and commissioning tests and report forms, commissioning schedules, and the exposure limits and calculation of gas levels in laboratories. Appendices also provide a list of substances which, in the quantities usual in school experiments, can be released safely in a fume cupboard meeting the recommendations outlined in this document. A glossary of terms concludes the document. (GR)

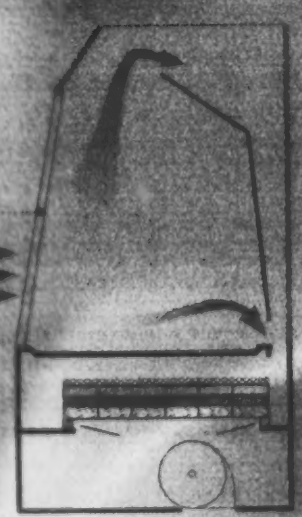
****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
This document has been reproduced as received from the person or organization originating it.
Minor changes have been made to improve reproduction quality.
Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY
John Birch
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
1

ED 431 292

FUME CUPBOARDS IN SCHOOLS





EF 005 386

Architects & Building Branch

Department for Education and Employment

D/EE

BEST COPY AVAILABLE

Building Bulletin 88

FUME CUPBOARDS IN SCHOOLS

(Revision of Design Note 29)

Architects & Building Branch
Department for Education and Employment

London: The Stationery Office

Preface

This Building Bulletin reviews the requirements for fume cupboards used in schools and colleges for teaching the sciences, mainly chemistry and biology, up to A-level GCE. It covers the level of provision that is desirable to meet curriculum needs and makes recommendations for good practice in the design, specification and installation of fume cupboards and their related extraction systems.

Acknowledgements

This bulletin has been produced by Architects and Building (A&B) Branch of the Department for Education and Employment. It was written and researched by David Tawney of the Consortium of Local Education Authorities for the Provision of Science Services (CLEAPSS) at Brunel University.

The Department for Education and Employment wishes to thank all those who have given advice and commented on drafts including:

- fume cupboard manufacturers and installers;
- school science inspectors;
- science teachers;
- science advisers;
- the Health and Safety Executive;
- and safety officers and others working for local government.

DfEE Project Team:

Mukund Patel, Head of Branch;

Chris Bissell, Principal Architect;

Richard Daniels, Senior Engineer

Illustrations by Sally Simpson

Crown Copyright 1998. Published with permission of the DfEE on behalf of the Controller of Her Majesty's Stationery Office

Applications for reproduction should be made in writing to The Copyright Unit, Her Majesty's Stationery Office, St Clements House, 2–16 Colegate, Norwich NR3 1BQ

ISBN 011 271 027 1

Contents

Page

Section 1: Legal requirements 1

Fume cupboard standards 1
Information, instruction and training 2
Monitoring and maintenance 2

Section 2: Recommended provision of fume cupboards in schools 3

Section 3: Choice of fume cupboards 4

Section 4: Specification of school fume cupboards 8

Design of fume cupboard systems 8
Working aperture 8
Face velocity 8
The sash 9
Internal dimensions 10
Duct exit position 10
Devices to improve air flow 10
Work surface 10
Lining and construction materials 11
Illumination 11
Services 11
Mobile fume cupboards 12
Filter fume cupboards 13
'Double sashed' fume cupboards 15
Information to be displayed 16

Section 5: The siting of fume cupboards 17

Section 6: Extraction systems 20

Design 20
Ductwork 22
The fan 23
Fume discharge 24

Section 7: Commissioning and monitoring fume cupboard systems 26

Commissioning and monitoring 26
Equipment for measuring air flow 27
Smoke tests 28
A fume cupboard log book 29

Section 8: Repairing and upgrading existing fume cupboards 30

Ducted fume cupboards 30
Filter fume cupboards 35

CONTINUED →

Page

Appendices

Appendix A: How a fume cupboard works 36

A1 General principles 36

A2 The effectiveness of fume cupboards 36

Appendix B: Monitoring & commissioning tests and report forms 38

B1 Instructions and report or for a visual examination 38

B2 Instructions for measurements of face velocity 39

B3 Initial face velocity and filter saturation record form 40

B4 Instructions for filter saturation testing of filter fume cupboards 41

Tests for saturation by acid gases:

B4.1 Method using a canister 41

B4.2 Method using burning sulphur 42

B4.3 Test for saturation by organic gases 44

B5 Record form for 14-monthly face velocity, filter saturation and visual examination 45

Appendix C: Commissioning schedules 45

C1 Statements for all fume cupboards 46

C2 Statements for demonstration and mobile fume cupboards 47

C3 Statements for filter fume cupboards 47

C4 Statements for ducted fume cupboards 48

Appendix D: Chemicals and reactions contained by Building Bulletin 88 fume cupboards 49

D1 Substances which can be released 49

D2 Procedures which can be carried out 50

Appendix E: Exposure limits and calculation of gas levels in laboratories 53

E1 Occupational exposure limits 53

E2 Calculations of exposure levels 54

Glossary 55

Further information 56

Section 1: Legal requirements

Fume cupboard standards

1.1 Employers[1], which may be LEAs or governing bodies depending upon a school's status, have a duty under health and safety legislation to ensure that the fume cupboards they provide adequately protect teachers, other users and pupils from exposure to hazardous gases. A duty which is further defined by the COSHH Regulations.[2]

The COSHH Regulations

1.2 Schools use gases which have hazard classifications or else have been given exposure limits (ie, Maximum Exposure Limits (MELs) or Occupational Exposure Standards (OESs)).[3] COSHH Regulation 6 requires that no work in which there is a risk of exposure to any of these gases is carried out unless the employer has had conducted a suitable and sufficient assessment of risks and taken steps to make these risks insignificant. In school science, releases of these gases cannot be totally prevented and so, under Regulation 7, they must be controlled, that is, their levels in the air kept below the exposure limits. The most usual method of control is a fume cupboard. General risk assessments, such as those in publications from the DfEE[4], CLEAPSS[5] and the ASE[6], specify when one should be used.

1.3 The employer's safety policy should make it clear who has the function of seeing that these risk assessments are followed; it is likely to be the head of science or someone to whom the function has been specifically delegated.

When fume cupboards should be used

1.4 As well as the general obligation of school staff to follow their employer's safety guidance, they have a specific duty under COSHH Regulation 8(2) to use a fume cupboard when risk assessments require it and to report any defects which may arise.

The standard of fume cupboard needed

1.5 The face velocity and filter efficiency recommendations in this publication are considered to provide an adequate standard for school fume cupboards as they are based on a study of risk assessments carried out for most known school operations involving hazardous vapours and gases, certainly all the common ones.[7] To produce a margin of safety, the quantities used were in excess of those that schools normally use.

BS7258 Laboratory Fume Cupboards

1.6 The air flow requirements of Part 1 of BS7258 are not appropriate for schools as its own foreword makes clear:

> *'Where it is known for particular fume cupboards that the rates of release of hazardous gases and vapours are low, or where the fume cupboards are used intermittently and then only for short periods, the performance type test procedure may be too stringent. In such situations, the requirements of this Part of BS7258 are not applicable and reference should be made to other appropriate standards such as Design Note 29 ...'.* ***(This building bulletin replaces Design Note 29, and is now the appropriate standard for school fume cupboards.)***

1.7 BS7258 excludes fume cupboards which are intended for demonstration, are mobile or fitted with filters. Many school fume cupboards are in these categories.

1.8 For the reasons given in the foreword to BS7258, a fume cupboard conforming to this Building Bulletin is adequate for school use and in one respect it is safer than one conforming to BS7258: face velocities are lower in order to reduce the risk of Bunsen burner flames being extinguished.

References

[1] Legally, the employer is the body with whom an employee has a contract of employment

[2] *The General COSHH ACOP, Carcinogens ACOP and Biological Agents ACOP* (one booklet), HSE, 1995, ISBN 0 7176 0819 0. Available from HSE Books, PO Box 1999, Sudbury, Suffolk, CO10 6FS.

[3] These are published annually in *Guidance Note EH40 Occupational Exposure Limits*, HSE Books. The ISBN changes annually. Available from HSE Books, PO Box 1999, Sudbury, Suffolk, CO10 6FS.

[4] *Safety in Science Education*, DfEE, HMSO, 1996, ISBN 0 11 270915 X, £14.95.

[5] *Hazcards, 1995*, available to members of CLEAPSS. See address in further information on page 56.

[6] *Topics in Safety, 1988*, ASE, ISBN 0 86357 104 2. From ASE, College Lane Hatfield, Hertfordshire, AL10 9AA.

[7] The investigations are reported in *'School Fume Cupboards'*, J R Crellin, Education in Chemistry 21 (6), November 1984, pp 185-8.

Information, instruction and training

Suppliers

1.9 It is a requirement of Section 6[8] of the Health & Safety at Work Act that suppliers provide articles which are safe and without risks to health. Further, they have to provide, with articles supplied, information adequate for their safe use. For fume cupboards, this should cover any restrictions on their use: eg, gases which cannot be contained or releases too large to be contained. It should also cover the necessary monitoring and maintenance procedures, eg, tests of filter saturation. A summary of this information, as described in paragraph 4.72, should be prominently and permanently displayed on the fume cupboard, not hidden in the back of a handbook.

1.10 The Health & Safety at Work Act requires adequate safety training; the COSHH Regulations[9] specify it for those who might be exposed to hazardous substances. Therefore, users of school fume cupboards must be instructed and trained to use fume cupboards when the risk assessments provided by the employer require it.

Monitoring and maintenance

The COSHH Regulations

1.11 Regulation 9 requires that equipment to control exposure is properly maintained. It must be thoroughly examined and tested every fourteen months and records kept of this. For school fume cupboards, monitoring and commissioning tests and record forms (Appendix B) with accompanying guidance notes (Section 7) have been agreed[10] with the Health & Safety Executive, both for ducted and filter fume cupboards.

Who can conduct the monitoring?

1.12 The notes agreed with HSE include suitably trained school laboratory technicians among those capable of carrying out the fourteen-monthly monitoring, provided that there is a procedure for referring borderline cases or inexplicable behaviour to a person or agency with more experience.

Failure to meet monitoring standards

1.13 It is important that a fume cupboard which fails to meet the standards stipulated in Section 7 and Appendix B is no longer used until it is repaired or upgraded so that it meets the standards. Alternatively, the operations carried out should be reviewed and a new assessment made of the risks of exposure; restricting the operations in various ways might enable some to be carried out but the onus would be on the employer to ensure that users were adequately protected.

1.14 A fume cupboard which fails to meet standards should be appropriately labelled as out of use or be used only for carefully-defined, restricted operations.

Intermediate checking

1.15 It is recommended[9] that, as well as the fourteen-monthly monitoring mentioned above, a fume cupboard be given a simple check to see that it is functioning, at least once a week. However, it is more practicable in school and college laboratories, where fume cupboards are used at irregular intervals, if this simple check is made before each use. One means is to observe a plastic ribbon acting as an air flow indicator, securely fixed to the working aperture at a suitable point.

References

[8] As amended by the Consumer Protection Act 1987, ISBN 0 10 544 3875, and modified by the Health and Safety (Leasing Arrangements) Regulations 1992, ISBN 0 11 024 5245, both from HMSO.

[9] *The General COSHH ACOP, Carcinogens ACOP and Biological Agents ACOP* (one booklet), HSE, 1995, ISBN 0 7176 0819 0. Available from HSE Books, PO Box 1999, Sudbury, Suffolk, CO10 6FS.

[10] At a meeting at the Department of Education and Science on 30 June 1989 at which representatives of the DES and the HSE were present.

Section 2: Recommended provision of fume cupboards in schools

Assumed usage

2.1 Appendix D gives lists of gases which can safely be released and of the procedures recommended[1] to be carried out in school fume cupboards.

2.2 The lists of procedures can be used as a basis for making risk assessments for other procedures including any which might be used in other courses, eg, GNVQ up to Advanced Level. However, if there is any doubt, those using fume cupboards should obtain specialist advice.[2]

Balanced science up to GCSE

2.3 Pupils in state secondary schools will follow the National Curriculum Science syllabus in Key Stages 3 and 4, that is up to GCSE. This includes activities requiring the use of chemicals; some of which will require a fume cupboard. When chemistry is taught separately at this level, a fume cupboard will be required more often. The need for a fume cupboard increases as courses progress. On some occasions the fume cupboard will be needed for demonstration (Section 3).

Key Stage 3

2.4 It is not necessary for every room used for Key Stage 3 science to have a fume cupboard but a fume cupboard will sometimes need to be provided, usually for demonstration, either by a mobile filter fume cupboard being wheeled in or by moving the class to a room where there is a suitable model.

Key Stage 4

2.5 At Key Stage 4, a fume cupboard is needed more frequently so that moving classes becomes more difficult. It may be most appropriate for any laboratory used at this stage to have a fume cupboard or have access to a mobile fume cupboard. Considering a science department as a whole, Key Stage 4 needs would require about half the laboratories to have a fume cupboard.

Normal use	Years	Number per room	Comment
KS3	7-9	-	Occasional access, usually to one suitable for demonstration.
KS4	9-11	0.5 - 1	Should be suitable for demonstration.
Post-16 chemistry (including A-levels)	12-13	2 - 3	Three is desirable if the class size is over 15. One should be suitable for demonstration.
Chemistry preparation	-	1	One is certainly needed in a preparation room used for work with chemicals.
Senior biology (including A-level)	12-13	-	Occasional access.
Biology preparation	-	-	Occasional access.

Table 2.1
Summary of recommended fume cupboard provision

Post-16 chemistry (including A-level chemistry)

2.6 In laboratories used for post-16 work, two fume cupboards are necessary, one suitable for demonstration, and a third may be useful for classes of fifteen or more. Increasingly, reactions such as organic preparations, carried out by pupils working in pairs, are considered to require a fume cupboard.

Post-16 biology

2.7 Sixth formers may need occasional access to a fume cupboard.

Preparation

2.8 Technicians servicing classes using chemicals need access to an efficient single-sashed fume cupboard for the dispensing of toxic, volatile substances or highly flammable liquids, for preparations involving these and for temporarily storing apparatus awaiting dismantling. It is desirable that this fume cupboard should be in the preparation room.

Summary

2.9 Because fume cupboard provision is expensive, it is natural to reduce it to the minimum. However, to do so can increase the temptation to carry out experimental work with hazardous gases in the open laboratory, greatly increasing the risk of problems caused by inhalation, particularly for asthmatics.

References

[1] The investigations are reported in *'School Fume Cupboards'*, J R Crellin, Education in Chemistry 21 (6), November 1984, pp 185-8.

[2] Employers should have an arrangement through which specialist advice for risk assessments can be obtained, eg, from the CLEAPSS School Science Service.

Section 3: Choice of fume cupboards

The two main questions to consider are:

- Is it to be used for demonstrations to the class?
- Is it to be mobile or fixed in position?

3.1 A demonstration fume cupboard needs to be glazed all round and positioned so that the demonstrator can stand at the aperture, with observers around all four sides. This is usually achieved by having a fume cupboard with some degree of mobility. This is often simply the ability to pull it out from the wall.

3.2 A mobile fume cupboard will usually be mounted on wheels but the extent that it can be moved will vary from just being pulled out from a wall to being moved from room to room. Factors which decide the degree of mobility of a fume cupboard are:

- whether it has a filter or a flexible duct;
- the availability of sites for the fume cupboard where there are no significant cross draughts and the air flow into it can be approximately perpendicular to the working aperture, giving a reasonable variation in face velocity;
- the provision, in different locations, of fixed ducts leading to extraction systems to which the flexible ducting can be connected and the ease of connection and disconnection;
- the provision of services.

3.3 Electricity, gas, water and drainage are needed to carry out the full range of activities which need the protection of a fume cupboard. Usually electrical socket outlets are mounted on the outside. Gas and water outlets (with a drip cup connected to the drainage system below the water outlet) are mounted inside the fume cupboard with their controls outside (see paragraphs 4.35-4.44).

Flexible service connections to mobile fume cupboards

3.4 If a fume cupboard is intended to be mobile, thought must be given to how the services are to be provided. If a drip cup is fitted, it should be connected via a flexible hose to the building drainage by a fitting in the floor or on the wall. This can be capped when not in use. The alternative of collecting the waste in a container which has subsequently to be emptied is hazardous.

3.5 For the supply of water and gas, there are two alternatives. The better is to have special outlets fitted for attaching flexible armoured hoses at the same locations as the capped drainage points. These hoses, the drainage hose and any flexible fume extraction duct need protection from strain by a cable limiting movement of the fume cupboard. With an arrangement in which the gas is controlled by a tap on the fume cupboard, it is important that the gas supply is shut off before the gas hose is disconnected. There are bayonet connections which cut off the supply as disconnection is made.

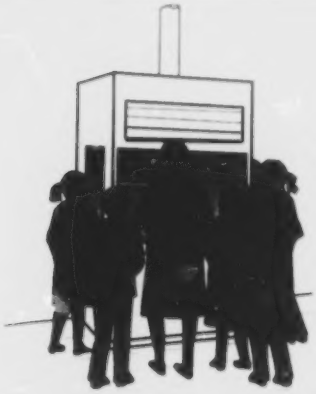
3.6 A less satisfactory alternative is to have no gas and water outlets on the fume cupboard; without a water outlet, no drip cup and drain are needed. If the use of a Bunsen burner is required, the mobile fume cupboard can be stationed close to a gas outlet on a bollard, bench, etc, and the burner connected to it and controlled from it in the normal way; care must obviously be taken that the hose does not form a hazard. If water is needed, perhaps for a condenser, it can be led from a water outlet on a bollard, etc, and returned to a sink.

3.7 The provision of electricity presents fewer problems although flexible cables, plugs and sockets must be maintained to a high standard.

Degrees of mobility

3.8 Special service points, particularly drainage points, tend to be expensive to install and technicians do not have the time to make the connections required, particularly if there is a drainage hose which needs to be thoroughly flushed out before disconnection and a flexible ventilation duct to be connected. In practice, fume cupboards intended to be moved from one position to another tend to stay in one position.

The advantages and disadvantages of the different possibilities, with and without services, are indicated below.



Position: Against a wall.

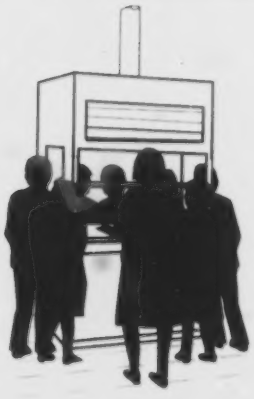
Services: Relatively easy to install if services are already available along the perimeter of the room.

Movement Possible: Nil.

Advantages: Not an obstruction. Simplicity of installation of service connections which need little maintenance. Can be installed in an existing laboratory by taking the duct out through the wall and up to roof level.

Disadvantages: Limited visibility through the front and, if glazed, the sides. Line of sight of pupils watching a demonstration is limited. Expense of ductwork.

Figure 3/1
Fixed, ducted, fully-serviced, against a wall, glazed front and sides



Position: Free standing.

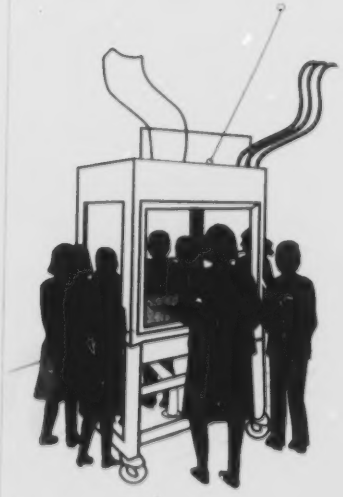
Services: Easy to connect only when a laboratory is being built.

Movement Possible: Nil.

Advantages: Visibility on all sides. Maintenance of ducting insignificant, unlike that of a fume cupboard connected by flexible ducting. Service connections need little maintenance.

Disadvantages: May be considered an obstruction. Difficult to install in an existing laboratory unless suitably-positioned services are already available. Expense of ductwork.

Figure 3/2
Fixed, ducted, fully-serviced, free-standing, glazed all round



Position: Pulled out from against the wall for use.

Services: Flexible lines to fixed points.

Movement possible: 1-2 metres, limited by length of drain connection. A restraining cable protects the ventilation duct and service lines. It is possible to move it to another room if there are special points for connecting ventilation and service lines.

Advantages: Visibility on all sides. Can be moved out of the way when not in use. Can be installed in an existing laboratory by taking the duct out through the wall and up to roof level and by coupling to existing perimeter services or a central bollard. No filter saturation tests needed, unlike a filter fume cupboard.

Disadvantages: Movement is limited. Flexible service lines are vulnerable and need care and maintenance, particularly the ventilation and drainage hoses. Location can be limited by trip hazard of low level service lines. Bench height lines can also cause an obstruction. Overhead services are a possibility. Expense of ductwork.

Figure 3/3
Mobile, ducted, fully-serviced, glazed all round.

BEST COPY AVAILABLE

Figure 3/4
Mobile, ducted, without services, glazed all round.

Position: Pulled out from against the wall for use.

Services: Nil.

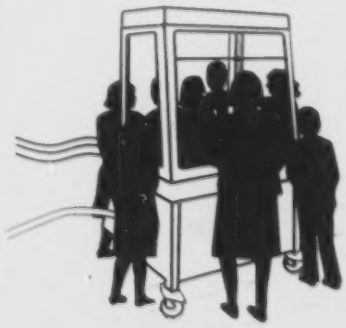
Movement possible: 1-2 metres, limited by a restraining cable to protect ventilation duct. It is possible to move it to another room if there is an outlet to which the ventilation duct can be connected. It is more likely to be moved than a serviced cupboard as there are no services requiring special connections.

Advantages: Visibility on all sides Can be moved out of the way when not in use. Can be installed in an existing laboratory by taking the duct out through the wall and up to roof level. No filter saturation tests needed, unlike a filter fume cupboard.

Disadvantages: Movement is limited. Water and drainage not available inside the cupboard. The flexible ventilation duct is vulnerable and needs care and maintenance. Expense of ductwork. No gas, water or electricity unless these can be brought as required from standard outlets close by.

This is a possibility if there are other, fully-serviced fume cupboards available. Gas and water for a condenser or a Bunsen Burner can be brought from standard outlets close by when needed.

Figure 3/5
Mobile, filter, fully-serviced, glazed all round



Position: Wherever there are special service outlets.

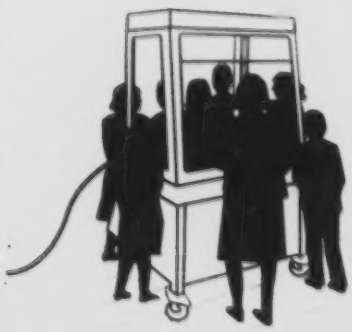
Services: Flexible lines to fixed points.

Movement possible: 1-2 metres, limited by length of drain connection. A restraining cable protects the service lines. It is possible to move to another room if there are special outlets for the service lines.

Advantages: Visibility on all sides. Can be moved to wherever there are special service outlets. Installation is less expensive than for a ducted fume cupboard.

Disadvantages: Filters have finite life and schools find them expensive to replace. Also, they need regular testing for saturation. Mobile fume cupboards are less robust.

Figure 3/6
Mobile, filter, without services (except electricity), glazed all round



Position: Wherever there is access to mains electricity.

Services: Only mains electricity.

Movement possible: Considerable. It is easy to move to another room provided there is a mains electricity outlet.

Advantages: Visibility on all sides. Can be moved to wherever there is mains electricity. Installation is less expensive than a ducted fume cupboard.

Disadvantages: Filters have finite life and schools find them expensive to replace. Also, they need regular testing for saturation. Water and drainage are not available inside the cupboard. No gas or water unless these can be brought as required from standard outlets close by. Mobile fume cupboards are less robust.

This is a possibility if there are other, fully-serviced fume cupboards available. Gas for a Bunsen Burner and water for a condenser can be brought from outlets close by when needed.

Table 3.1
Ducted and filter fume cupboards compared

	Ducted fume cupboard	Filter fume cupboard
Installation	Requires ductwork, a fan and a stack discharging well above the roof line and so is difficult and expensive to install, particularly in an existing building.	No building work but purchasers should check if the fume cupboard is assembled for them on delivery. An initial test is needed to ensure the filter is properly seated (Appendix B4).
services	The installation of services (ie, electricity, gas, water and drainage) for both ducted and filter fume cupboards is similar.	
Mobility	Filter fume cupboards do not require a duct but mobility of both types is limited by the provision of services.	
Robustness	Glazing is with toughened or laminated glass. The main construction is of timber and timber products, mild steel or anodised aluminium. Construction tends to be heavier than that of filter fume cupboards.	Glazing is usually with acrylic although polycarbonate is stronger. The most common construction material is mild steel. Construction is lighter than that of ducted fume cupboards.
Visibility	This depends on whether there is all-round glazing and where the fume cupboard is sited, not on whether the fume cupboard is of the ducted or filter type.	
Protection	Will protect adequately against normal releases of all hazardous gases in school science.	Will protect adequately against normal releases of all hazardous gases except hydrogen and carbon monoxide.
Monitoring air flow	The fourteen-monthly air flow monitoring and examination of service fittings, etc, is the same for both types (see paragraphs 7.9-7.12)	
ducts	Ducts should be inspected for leaks and discharge points for blockage. The cost of monitoring by an outside contractor will depend on the total number of fume cupboards in the school.	
filters		Filters need to be checked for saturation periodically. This can be done by suitably trained school staff (Appendix B4). Because of this additional test, the cost of a full service by an outside contractor is considerably more; it should depend on the number of filter fume cupboards in the school. Electronic filter-failure detectors have not yet been shown to be reliable for the range of gases used in schools over the time-scale required. Provision must be made for the cost of filter replacement.
Maintenance and repairs *(see Section 8)*	Little maintenance is needed. Some repairs can be done by local companies. Specialist companies often do not charge for an initial visit.	Filters need to be replaced periodically and schools find them expensive. The manufacturer is usually needed for any repair and schools consider the call-out charges to be high.
Heat losses	It is sometimes claimed that filter fume cupboards offer significant savings because they do not extract warmed air from the building. However, most school fume cupboards run for only a small proportion of the time so that the loss is not significant.	

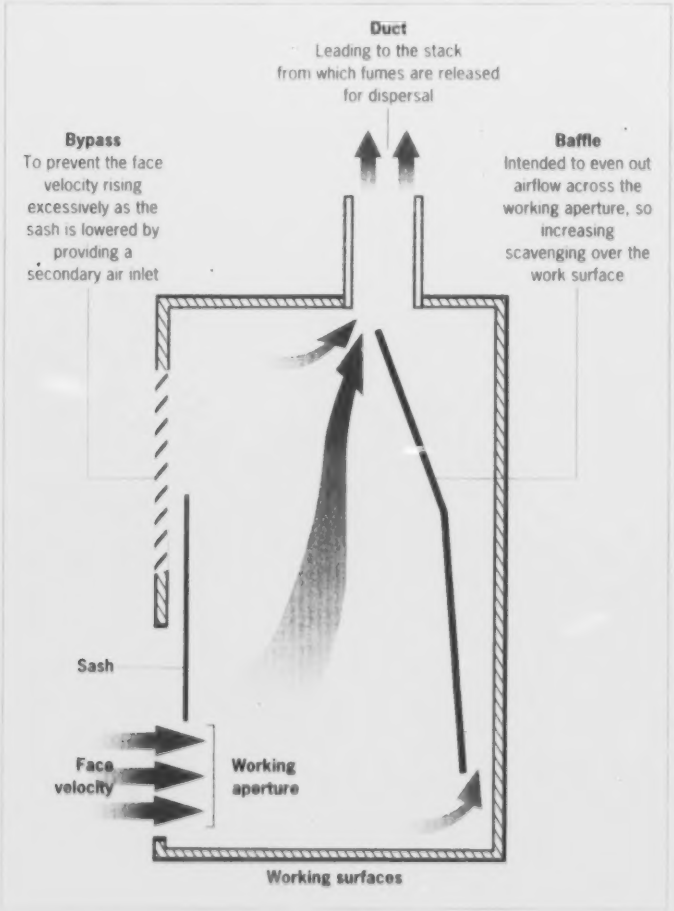
Section 4: Specification of school fume cupboards

This section contains descriptions of the various types of fume cupboards and suggested specifications to apply when purchasing a new fume cupboard. An existing fume cupboard should meet the minimum pass criteria for a visual inspection (column 3 of form in Appendix B1) and the face velocity requirements (see Appendix B2). The specifications in this section will be useful when upgrading existing fume cupboards above these minimum standards.

Design of fume cupboard systems

4.1 Fume cupboard systems must be considered at an early stage in the design of a building as provision may need to be made for ductwork, including a stack; the architect and others concerned with the design are advised to consult a specialist supplier.

Figure 4.1
A ducted fume cupboard with some features explained


Duct
Leading to the stack from which fumes are released for dispersal
Bypass
To prevent the face velocity rising excessively as the sash is lowered by providing a secondary air inlet
Baffle
Intended to even out airflow across the working aperture, so increasing scavenging over the work surface
Sash
Face velocity
Working aperture
Working surfaces

4.2 Within a laboratory or preparation room, siting needs to be considered in relation to the position of doors, windows and other air inlets and outlets, particularly any air inlet designed to provide an adequate supply of make-up air (Section 5). The design of the complete system should be by, or at least approved by, a suitably-qualified engineer who is familiar with this publication and a suitably-qualified engineer should also supervise the installation.

Working aperture

4.3 The working aperture is the opening through which the users can put their arms. If its height is too small manipulation of apparatus is restricted; If it is too large it can be hazardous as it is harder to keep the variation in air flow across the aperture low and to make the bypass effective; it also requires a more powerful extraction system.

Face velocity

4.4 The face velocity standard is based on containment investigations made on school fume cupboards. The measurement procedure is given in appendix B.

4.5 With the sash set for the full working aperture, the face velocity (at the centre of any cell averaged over a period of at least 10 seconds as in Appendix B2) shall not be below 0.3ms^{-1}. Individual readings taken across the face must not deviate more than 30% from the mean value.

4.6 Care must be taken to ensure that the face velocity at full working aperture is not too high. Otherwise, lowering the sash may increase the face velocity sufficiently to blow out Bunsen burner flames. An efficient bypass will reduce this effect (see paragraphs 4.23-4.25).

4.7 The variations in favourable conditions should be below $\pm$20%. However, because it is difficult to find ideal sites in many school laboratories, $\pm$30% has been stipulated.

4.8 Ideally, face velocity measurements should be made at each position where a mobile fume cupboard is to be used.

Flow indicator

4.9 Fume cupboards should be fitted with a simple device which can be observed to show that air is flowing into the fume cupboard. A suitably positioned, firmly-secured light plastic ribbon is adequate.

The sash

Is a movable sash needed?

4.10 Lowering the sash of a modern ducted fume cupboard with a well-designed bypass will not affect containment significantly. Therefore, while fume cupboards must have a sash, the relative advantages in having a movable one are more perceived than real; further, it is easier to obtain low variation with a fixed-height working aperture. The folding sashes of filter fume cupboards are, in effect, fixed sashes.

4.11 It is useful to be able to lower the sash for the subsidiary use of a fume cupboard as an enclosure giving protection against minor explosions, bursts, splashes etc, However, this is no substitute for wearing eye protection.

4.12 A movable sash should be supported by a counterbalance or spring system to enable it to remain at any position where the user puts it. It should not be difficult to gain access to this system for inspection and repair. Any counterbalance system should jam if a cable or cord breaks and not allow the sash to fall. The cable or cord supporting any counterweight should be inspected annually. The sash should be glazed with a safety material (see paragraph 4.32).

The sash; maximum and minimum stops

4.13 Sashes of ducted fume cupboards vary the height of the working aperture.

4.14 With ducted fume cupboards installed before the 1980s, lowering the sash is likely to raise the face velocity considerably. It is common practice to lower the sash once a reaction has been established, in order to improve containment by increasing face velocity. However, care must be taken that the increase in the velocity of the air inside the fume cupboard does not affect the efficiency of any Bunsen burner or even extinguish it; nor must it create excessive turbulence.

4.15 It should not be possible, during normal use, to raise the sash so much that the face velocity falls below 0.3ms $^{-1}$. It is therefore important that the height of the working aperture is limited, preferably with a stop, to prevent the user opening it too much. The stop should be of such a design that it can be over-ridden, eg, with a key, to give a bigger aperture for assembling equipment or cleaning. The height of the bottom edge of the sash or its frame above the lip or raised edge of the work surface at the full working aperture should be at least 400mm. It should not be possible to raise the sash above this full working aperture in normal use. A minimum height stop should prevent the sash closing completely as this prevents extraction from the fume cupboard; in its lowest position, the gap under it should be no less than 50mm high.

4.16 A height of 400mm or a little more allows manipulation of apparatus in the fume cupboard but provides some protection to the face of the user. A higher aperture reduces this protection, makes it more difficult to obtain an airflow which does not increase too much as the sash is lowered and increases the difficulty of fitting an efficient bypass.

Internal dimensions

4.17 It is assumed that the fume cupboard will be rectangular.

4.18 The minimum internal width is 900mm. This allows only one procedure to be carried out in the fume cupboard at a time. Two cupboards of this width are safer than one of, say, 1500mm width in which it is likely that two simultaneous operations will sometimes be attempted, not a safe practice. A narrower cupboard gives an insufficient area of work surface clear of service fittings.

4.19 An internal depth of 500mm is recommended. If a fume cupboard is much deeper, users will find it difficult to reach the back through the normal working aperture and may be tempted to use it for storage. A shallower cupboard gives insufficient area of work surface clear of service fittings.

4.20 The minimum internal height for a fume cupboard with movable sashes is 900mm. Reducing the height of a fume cupboard makes it difficult to achieve a low variation in face velocity. If it has a movable sash, a low height makes it difficult to have an effective bypass (see paragraphs 4.23- 4.25). 750mm is the minimum for fume cupboards with fixed sashes. This is required for the tallest apparatus.

Duct exit position.

4.21 The duct exit should be at the middle of the width of the top of the fume cupboard. This is to reduce variation of the face velocity across the working aperture.

4.22 The position of the exit in relation to the front and back of the fume cupboard must be considered simultaneously with the design of the baffle. The aim is to reduce variation of the face velocity across the working aperture.

Devices to improve air flow.

The bypass

4.23 A fume cupboard with a sash should be fitted with a bypass (also called a secondary air inlet) whose purpose is to prevent much increase in face velocity as the sash is lowered and to maintain a stable air flow (see Figure 4.1).

4.24 It is recommended that each school fume cupboard should have its own extraction system (Section 6) and, with this, the bypass should be designed to keep the face velocity constant and so remove any risk of Bunsen burner flames being affected.

4.25 It is essential that a bypass is fitted in any fume cupboard with a movable sash. It is recommended that a bypass should not allow the face velocity to rise by more than 50% when the sash is lowered from its position at full working height to 200mm.

The baffle

4.26 A baffle is desirable as a means of reducing variation. A fume cupboard with a large internal height may not need a baffle to produce a variation in face velocity below ±30%.

4.27 If a baffle is fitted, it must be such that it can, for cleaning, be easily removed and replaced in the correct position. It is essential on a demonstration fume cupboard that the baffle is transparent and kept clean.

Work surface

4.28 Suitable materials include melamine-surfaced phenolic resin, filled acrylics, solid epoxy, moulded glass-reinforced epoxy laminate and suitably grouted ceramic tiles. It is important that plastic materials are dark coloured as the stains produced by hot objects and most chemicals tend to be orange-brown.

4.29 Stainless steel can be blackened, pitted and even holed by solutions containing chloride ions, eg, hydrochloric acid or bleach, particularly in the presence of particles of metal. If it is used, it should be grade 316 rather than the grade 304 for domestic use.

4.30 The work surface should be dished or its front should have a lip to prevent spilt liquids running out of the front of the cupboard; the lip should be shaped for easy cleaning. If the work surface is flat with a lip at the front, it should be sealed round its other edges with a suitable material, for example, silicone rubber mastic. The work surface should be approximately level with other work surfaces in the laboratory, which are usually about 850mm above the floor.

Lining and construction materials

4.31 Materials should be resistant to fire and to chemicals and be non-absorbent. Safety glass, acrylic, polycarbonate, melamine and epoxy-coated or stove-enamelled aluminium or steel are suitable. Wood, plywood, suitably veneered and treated blockboard, chipboard or medium density fibre board can be suitable if treated with flame retardant and chemical resistant coatings or finishes.

Glazing

4.32 The sash of a fume cupboard must be glazed and, if used for demonstration, the fume cupboard should have a glazed back and sides. Protective glazing must be used: toughened glass or laminated glass at least 5mm thick; or acrylic, or polycarbonate. Protective glazing is necessary because there is a risk of pupils running into a fume cupboard and, also, a very slight risk of an explosion inside. Georgian wired glass is not a safety glass. Acrylic is less strong than polycarbonate. If a fume cupboard is to be illuminated by general room lighting, then it must be glazed elsewhere besides the sash.

Illumination

4.33 Good illumination aids safety and is essential for demonstration. A maintained illuminance of at least 300 lux on the work surface is required. One or more suitable lamps should be built into the fume cupboard unless the fume cupboard is extensively glazed and to be used in an area already very well illuminated.

4.34 Light fittings must prevent ingress of gases released within the fume cupboard to reduce the slight risk of igniting flammable vapours and to avoid corrosion.

Services

Electricity

4.35 Unless mobile, the wiring to a fume cupboard should be permanent. The extract system should not be wired from a Residual Current Device(RCD) which protects socket outlets or other equipment. A fault on one of the sockets or other equipment could trip the RCD and cause the extract system to be switched off and allow fumes to escape.

4.36 A switched double-socket outlet, with integral indicator lights and protected by an RCD, is needed and should be placed on the front of the cupboard close to the work surface and near to one side. If necessary, it should be protected from drips by an anti-drip groove below the edge of the work surface which should protrude sufficiently.

Gas[1]

4.37 One supply point is needed, and two are desirable, placed on or just above the work surface near to the front and to one side of the cupboard.

4.38 The controls should be outside the cupboard, on the front and below the work surface.

Reference

[1] See also *'Guidance Note on Gas Safety in Educational Establishments'* 1st edition, 1989. This provides guidance on the safe installation and operation of gas equipment in laboratories. Available from The Institute of Gas Engineers, 21 Portland Place, London, W1N 3AF. Tel: 0171 636 6603 Fax: 0171 636 6602.

4.39 Systems in which the control knob and valve are connected through rods should be avoided. They can be hazardous as pupils do not understand the play inherent in them and may damage them with excessive force. Panel mounted valves are more reliable.

Water and drainage

4.40 Fixed fume cupboards need one water supply, on or just above the work surface near to the front and close to the side. Again, the controls should be outside, on the front and as direct and simple as possible. As for gas, rod systems can be damaged and should be avoided. Panel mounted valves are more reliable.

4.41 There should be a small drip cup, fitted into the work surface without any lip, below the water outlet and connected to the main drain via a bottle trap. Its purpose is to receive water from the tap, the outflow from condensers and to aid the clear-up of spills.

4.42 If the service outlets and drip cup are too far back, users are tempted to put their heads inside the fume cupboard to use them. They must be near to the side to leave a clear area of the work surface for apparatus.

4.43 A bottle trap should be adequate to protect the drains from chemicals; a dilution trap should not be needed.

4.44 In a preparation room a small sink is sometimes requested instead of a drip cup. This is not recommended because it reduces the working area inside the fume cupboard and encourages the tipping of hazardous chemicals into the drainage system. They must be diluted and/or neutralised first.

Protection of piped services

4.45 It is not recommended to store chemicals under a fume cupboard. Nevertheless, if a cupboard below the fume cupboard is intended as a store for corrosive volatiles, it must be sealed off from any pipes, cables and fittings. It should be fitted with a polypropylene inner cupboard and a vent made directly through the back and through the wall behind to the outside and fitted with a vent grille. A hazardous chemical warning label should be fitted to the cupboard door.

4.46 If natural ventilation to outside is not possible, such a cupboard should have regular mechanical ventilation, perhaps by ducting it to the fume cupboard system. The ventilation should be controlled by a timeswitch so that the volatiles cupboard is ventilated at least twice daily.

Service connections

4.47 If a drip cup is fitted it should be coupled with proper fittings to a drain and not to a container underneath the cupboard. Leading the waste from the drip cup to a container can present hazards if noxious liquids are poured or spilt into it.

4.48 If there is no water outlet on the fume cupboard (and no drip cup etc) and water is needed for a condenser, it can be supplied via hoses from a nearby sink. For this purpose, it may be useful to have two short metal tubes passing through the side of the cupboard at low level. The manufacturer should be consulted on their size and position as they might affect the air flow.

Mobile fume cupboards

4.49 Care must be taken to ensure that cables and hoses bringing services to a mobile fume cupboard do not present any hazard. In particular, the gas supply to an outlet with a control on the fume cupboard must be properly plumbed; any hose should be reinforced or armoured and securely attached to rigid fittings at either end. To prevent hazards it should not be possible to disconnect the gas hose without the supply being cut off first or simultaneously at the fixed outlet.

Stability of mobile fume cupboards

4.50 It should be possible to prevent a mobile fume cupboard moving during use. One method of achieving this is to fit two wheels with locking devices which are easy to apply and release.

Flexible Ducting

4.51 If a mobile fume cupboard is of the ducted type, the extraction fan must never be fitted on top of it but to the fixed ducting so that the interior of the flexible ducting is at negative pressure. With the flexible ducting at negative pressure, any defects in it will lead to leaks into the system rather than out of it.

4.52 Flexible ducting should be designed so that there are no low points where condensation can settle when the fume cupboard is either in its working or parked position. The movement of a fume cupboard must be limited with a cable to ensure that its duct connections cannot be strained or wrenched off.

4.53 Suppliers are reminded of their obligation under the Health & Safety at Work Act, Section 6, to provide full information to ensure safe use. (see paragraph 1.9)

Noise (see paragraphs 6.20-6.22)

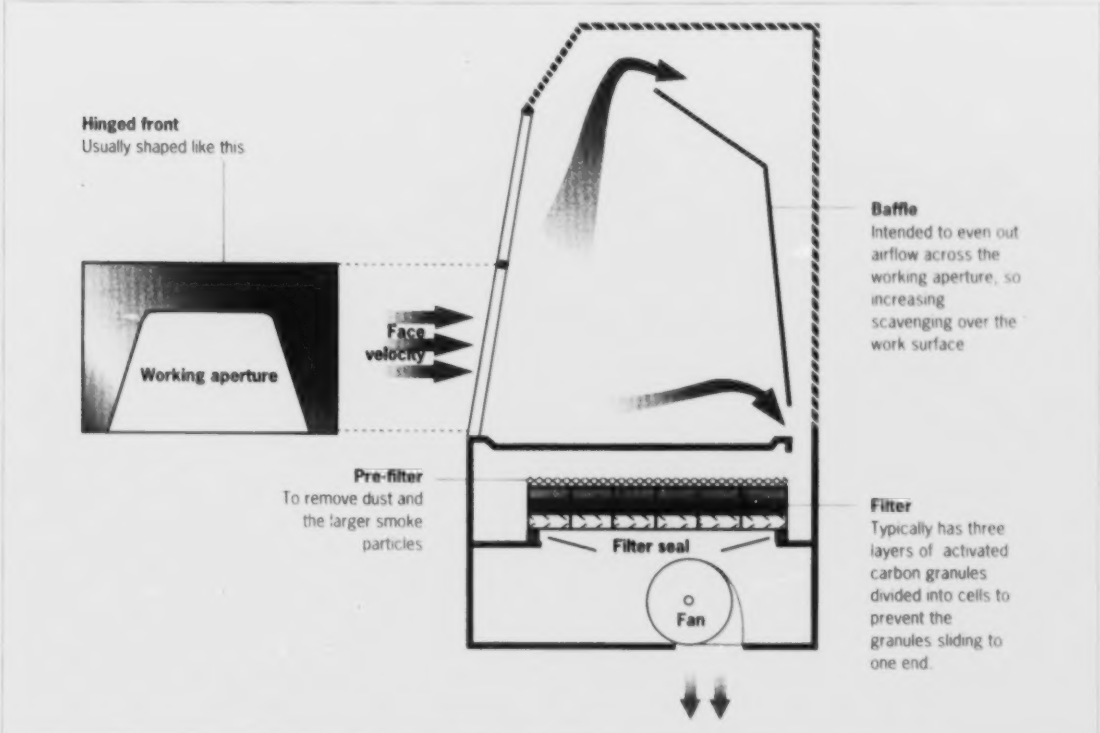
Filter fume cupboards

4.54 The filter is most commonly fitted below the work surface as shown in Figure 4.2. However, some models have the filter above the working chamber.

The working aperture

4.55 Filter fume cupboards do not usually have a sash, whose position can be continuously varied, but an arrangement of hinged flaps. This implies an aperture with a fixed working height, for although flaps can be raised to give more than one size of aperture, it is usually only with the flaps fully down that the face velocity will be adequate.

Figure 4.2
A filter fume cupboard with some features explained


Hinged front
Usually shaped like this
Working aperture
Face velocity
Baffle
Intended to even out airflow across the working aperture, so increasing scavenging over the work surface
Pre-filter
To remove dust and the larger smoke particles
Filter seal
Fan
Filter
Typically has three layers of activated carbon granules divided into cells to prevent the granules sliding to one end.

4.56 The top and sides of the working aperture are usually determined by a cut-out in a flap; the bottom is determined by the work surface.

4.57 It is difficult with a filter fume cupboard to achieve the working aperture height of 400mm. Whilst designers should aim for a height of at least 400mm, 360mm is considered acceptable. It is also permissible to restrict the width of the aperture.

The pre-filter

4.58 To prevent the main filter from becoming clogged with dust, the contaminated air first passes through a pre-filter which resembles a thin layer of wadding. The pre-filter will also extract smoke particles whose size is 0.5 x 10^{-6}m (μm) or above; finer particles will pass through.

Composition of the main filter

4.59 The main filter consists of activated carbon suitably treated for the hazardous gases which need absorption. As illustrated in Figure 4.2, three layers are typical: for acid gases, for alkali gases, mainly ammonia, and for hydrogen sulphide. All three layers will absorb organic gases. A typical filter has solid plastic sides and a porous top and bottom. It is divided into cells by plastic dividers to keep the carbon granules evenly distributed.

Filter mechanism

4.60 The mechanism of filtering is not like that of a coffee filter which separates particles from a liquid. Rather, a gas in the air passing through the filter divides, most becoming attached to the activated carbon but some remaining in the air, the relative amounts determined by a ratio which depends on the gas, the particular type of activated carbon, etc. This means that, although a very high percentage of the gas will be absorbed (eg, 97%), some will always pass through, not sufficient to present a hazard but enough sometimes to be smelt.

4.61 The rate at which the gas-contaminated air passes through the filter is critical. If it is too fast, the time the air spends inside the filter is too short for adequate absorption. If it is too slow, the face velocity may become too low for adequate containment.

Choice of filter

4.62 The composition of filters can be varied to absorb different hazardous gases. However, a school would find it difficult to specify a filter to meet its needs and these could change. It is suggested that schools buy filters intended to absorb all the gases likely to be encountered in school science and which have been verified to do so by an organisation independent of the supplier: see Table 4.1 for a suitable specification.

Reference in table

[2] See Appendix E2. The calculation is based on a release for 30 minutes in a 250m³ room with a ventilation rate of two changes of air per hour (a low value). The K value is 2 as the fan in the cupboard will help distribute the gas more quickly within the room (K is taken as 10 in undisturbed rooms).

Table 4.1
Filter efficiencies required

Substance	% Efficiency required	Examples of release rates of gas in fume cupboard ($cm^3 s^{-1}$)		Release into room ($cm^3 s^{-1}$)	Level of gas within the room (ppm)[2]
Ammonia	96.5	100	(preparation)	3.5	20
Bromine	98.5	2	(pouring)	0.03	0.2
Chlorine	99.0	12	(preparation)	0.1	0.6
Nitrogen dioxide	96.5	7	(preparation from copper and concentrated nitric acid)	0.25	1.5
Sulphur dioxide	99.0	50	(opened sulphur dioxide canister)	0.5	3
1,1,2-trichloroethylene	97.0	50	(boiling)	1.5	9

Cost and life of a filter

4.63 A pre-filter costs only a few pounds but is usually sold in a pack containing several. Typically it will need replacing every six months. A main filter usually costs £150-200 and, with normal school use, will last from two to five years.

Testing filters for saturation

4.64 If pre-filters become blocked with dust, there will be a drop in face velocity. (Appendices B2 and B3) Some filter fume cupboards have electronic monitors which will indicate this. Failure of the main filter to absorb adequately can be monitored reliably only by releasing a gas inside the cupboard and checking its concentration in the exhaust (Appendix B4). Electronic detectors have not yet been shown to be sufficiently reliable.

Safety

4.65 Filter fume cupboards have been used in schools since the early 1980s and there is no evidence to suggest that they are unsafe if they are used properly, if their filters meet the specification in Table 4.1 and if they are regularly monitored for air flow and filter saturation. However, suppliers of filter cupboards, like all suppliers, have a duty to ensure that their products are safe if used in accordance with their instructions.

Filter specification

4.66 By law, it is the duty of the supplier to ensure that the fume cupboard operates safely.

In particular, the supplier must be sure that there are no significant risks of:

- desorption or of dangerous reactions occurring within the filter between substances absorbed at different times;
- fire or explosion from the fan, lighting equipment or Bunsen burner flames during work with flammable gases or vapours or involving any possible escape of flammable vapours or gases, perhaps when a filter becomes saturated;
- a fire involving the fume cupboard either causing explosion risks from a substantial amount of flammable substances previously absorbed in the filter or danger from the desorption of toxic gases.

4.67 The absorption efficiencies of the filter should conform to those specified in Table 4.1.

4.68 There must be a means of detecting when a filter is approaching saturation, reliable over the life of the filter which, in a school, could be as much as 5 years. Any automatic detector should give a reliable and unambiguous warning for all acid gases used in school science without requiring frequent adjustment by the user.

'Double sashed' fume cupboards

4.69 Fume Cupboards with two openings are not recommended. Typically, fitted between two rooms, such fume cupboards reduce security and fire resistance and, above all, do not provide adequate containment; it is impossible to comply with the minimum height stop requirement and still prevent cross-draughts.

4.70 The face velocity under one sash will be affected by the position of the other. It is much safer to have two separate fume cupboards, with separate extraction systems.

4.71 These fume cupboards should not be confused with the other type, also known as 'double sashed' which have a single opening and a horizontally split sash. These split sash cupboards can be useful where there is a restricted floor to ceiling height.

Information to be displayed

4.72 The following should be prominently displayed on the fume cupboard:

- The manufacturer's and installer's names and addresses.
- The model, serial number and dates of supply and installation.
- An indication of the sash positions, or of the arrangements of a folding flap-type front, which are necessary to ensure that working aperture height and minimum face velocity requirements are met.
- A permanent label should indicate the highest safe position of the sash and make it clear that, if the maximum height stop is released so that the sash can be raised further, it is only for setting up apparatus, etc, not for releasing chemicals.
- A warning that there is a legal obligation to check the fume cupboard, particularly its face velocity, at least every fourteen months; also, to check it visually to see that it is working before use. (see paragraph 1.15)
- In addition, on a filter fume cupboard, there should be, prominently displayed, lists of the hazardous gases commonly released in school science which the filter will and will not absorb adequately. Warnings are also required that both face velocity and filter efficiency need regular checks and where instructions for these checks can be found. The need for setting and checking any saturation detectors must be prominently displayed. Instructions for all checks should be given in a handbook.

Section 5: The siting of fume cupboards

The siting of a fume cupboard should be considered at an early stage in the design of a laboratory. The location should be approved by the engineer designing the whole fume cupboard system. Because of the space limitations of school laboratories, it is seldom possible to meet all the requirements suggested below. Compromise is often necessary.

Minimum distances to avoid disturbances to operation of the fume cupboard

5.1 The following distances, largely in accordance with BS 7258 part 2: 1990 (See Figure 5.1) apply to all school fume cupboards:

1. The distance from the working aperture to any circulation space should be at least 1000mm, (see Figures 5.1(a) and 5.1(c)).
2. There should be no opposite wall (or other obstruction likely to affect the airflow) within 2000mm of the working aperture (see Figure 5.1(d)).
3. No fume cupboard should be installed in a position where it is likely to be affected by any other item of equipment. In particular, no other fume cupboard should be less than 3000mm from the working aperture (see Figure 5.1(e)).
4. Any room air supply inlets should not be located within 3000mm of the working aperture.
5. No fume cupboard should be positioned with either side closer than 300mm from a wall or similar obstruction (see Figure 5.1(f)).
6. No large obstruction (eg, an architectural column) in front of the plane of the working aperture should be within 300mm of the side of the fume cupboard (see Figures 5.1(g) and 5.1(h)).
7. No doorway or opening window should be within 1500mm of the sash or within 1000mm of the side of a fume cupboard (see Figures 5.1(i) and 5.1(j)) except where a door includes an air transfer grille.

Visibility

5.2 The minimum distances may need to be increased in practice to provide sufficient space for pupils to gather round to observe experiments.

5.3 For demonstration purposes an unobstructed working zone of radius 2m from the centre of the fume cupboard is recommended. This zone would accommodate 15 to 20 pupils with some sitting and others standing.

5.4 In practice 2m is difficult to achieve even with moveable furniture and the minimum radius of 1.5m is more realistic (see Figures 5.1(b) and 5.1(c)).

5.5 Even if a fume cupboard is not required for demonstration to the whole class, a minimum radius of 1.5m is recommended to allow for pupils watching or waiting to use it.

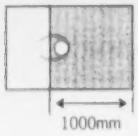
5.6 Fume cupboards in prep rooms can abut benches as they are not normally used for demonstration and so do not require visibility from three sides.

Air inlets

5.7 The relationship of a fume cupboard to air inlets should be such that the flow of air to the fume cupboard is nearly perpendicular to its face.

5.8 Increasing the distance from doors and windows minimises the effects of disturbances, caused by doors opening and shutting and fluctuations in the wind. (If a fume cupboard has to be near a door, draughts caused by its opening and shutting can be reduced by the fitting of an air transfer grille and a suitable door closer.

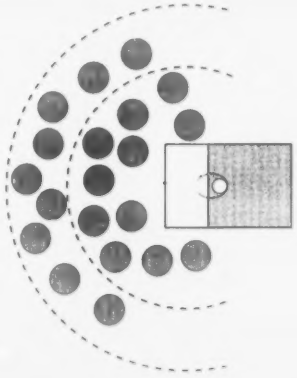
a. Fume cupboard with undisturbed zone (area in which air should be undisturbed by anyone other than the operator)



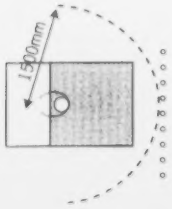
b. Fume cupboard with optimum working zone for demonstrations of radius 2m in front and to the sides of the fume cupboard, showing 20 pupils sitting and standing.

Also shown is the minimum recommended working zone of radius 1.5m.

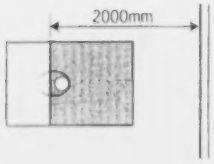
Fixed benches and furniture ideally located outside this working zone.



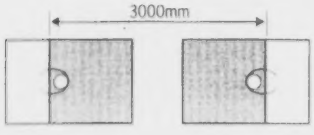
c. Circulation route shown on border of 1.5m minimum recommended working zone



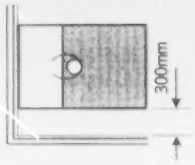
d. Spacing of 2000mm from wall or obstruction above worktop height, determined by air flow requirements



e. Spacing of 3000mm between working apertures of fume cupboards determined by air flow requirements

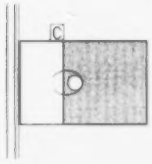


f. 300mm side spacing from full height obstructions such as walls or tall cupboards determined by air flow requirements



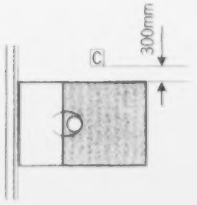
g. Spacings that avoid undue disturbance of air flow

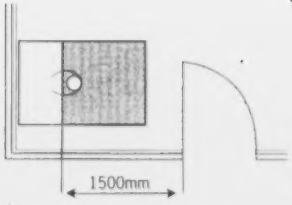
Face of column not in front of plane of sash



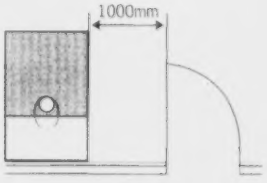
h. Spacings that avoid undue disturbance of air flow

Face of column in front of plane of sash





i. 1500mm spacing from sash to doorway or opening window



j. 1000mm minimum spacing from side of fume cupboard to opening doorway or window

Figure 5.1
Recommended distances for location of fume cupboards

Obstructions

5.9 The area in front of the sash of a fume cupboard should be as free as possible from anything which will affect the air flow to it, for example walls, pillars, tall cupboards, etc.

5.10 The shape of most school laboratories and the need for sufficient space round a fume cupboard for observers make obstructions to the air flow unlikely. However, mobile ducted fume cupboards should be able to be pulled out so that the side with the sash is about 2m from the wall (see Figure 5.1(d)).

5.11 It is important to bear in mind the need for a clear area in front of a fume cupboard when siting one in a preparation room.

Circulation routes

5.12 A fume cupboard should be sited away from circulation routes.

5.13 Passers-by create eddies, causing escapes from the fume cupboard, and can distract or even knock into its user. However, during the brief period a demonstration is likely to take, this may not be significant.

Exits to rooms

5.14 Fume cupboards should preferably be located away from exit doors, particularly if there is only one exit from a room. If an accident occurs in a fume cupboard or if its extraction system fails, it may be necessary to evacuate the room which may be made harder if it is sited near to an exit.

Section 6: Extraction systems

It must be stressed that the protection of fume cupboard users depends as much on the design of the extraction system and its installation as on the fume cupboard itself.

Design

6.1 The design of all extraction systems for fume cupboards should be by, or receive the approval of, a suitably qualified engineer.

6.2 The total system resistance should be calculated from CIBSE data,[1] account being taken of the resistance offered by the fume cupboard, ductwork and any dampers.

Reference

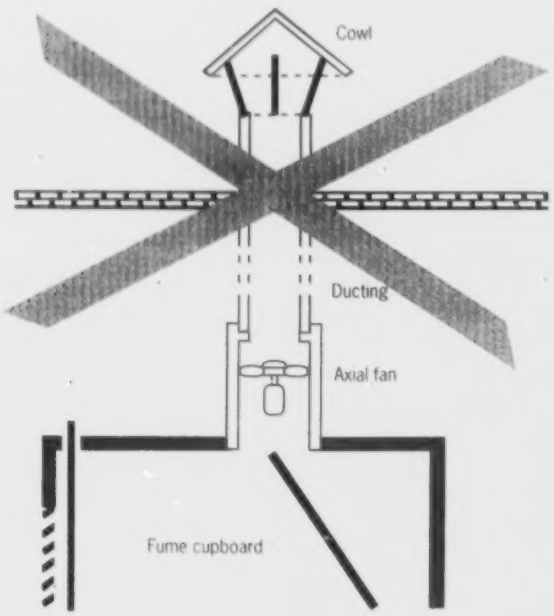
[1] *'Flow of fluids in pipes and ducts'*, Section C4, Chartered Institution of Building Services Engineers Guide, 1977, ISBN 0 900 953 314 from CIBSE, Delta House, 222 Balham High Road, London, SW12 9BS.

6.3 There have been reports of inadequate systems being installed, of inadequate upgradings and of systems being made inadequate by building alterations. Aesthetic considerations, the need for planning approval etc, may make a solution difficult to find but it must be totally safe.

6.4 Figure 6.1 shows a traditional installation with an axial fan situated just above the fume cupboard. It has the disadvantage of being noisy; further, the pressure in most of the ducting will be positive so that fumes will leak out of any holes or cracks. Also, fumes are discharged too close to the roof level and the discharge is impeded by a cowl. This arrangement should not now be installed.

Figure 6.1

Traditional system of extraction



6.5 Figure 6.2 shows two typical modern installations, each with a centrifugal fan situated outside the building. A centrifugal fan gives an air flow less affected by the position of the sash than an axial one and is less noisy.

Individual or shared extraction systems

6.6 Each fume cupboard should preferably have its own extraction system. If an extraction system is shared, then all the fume cupboards on the system will need to be on or off simultaneously with an indicator light by each fume cupboard to show when the system is on or off. A shared system also needs a damper fitted to each fume cupboard and an effective bypass.

6.7 With a shared system, there is a hazard that it may be switched off when fume cupboards are in use. Having to run all fume cupboards when only one is needed increases heat losses. Further, while the noise of a fume cupboard in a particular laboratory is tolerated if it is being used, it will not be if it has to be switched on because another is needed elsewhere.

6.8 Fume cupboards should be able to be operated independently of general laboratory ventilation systems.

Siting of the fan

6.9 The fan should be sited outside the building and as near as possible to the discharge point of the extraction system. Where this is not practicable, any ductwork under positive pressure should be rigid and particular attention paid to ensuring that joints are, and remain, airtight.

26

6.10 This means that as much as possible of the system is under negative pressure, ensuring that, at any failures of integrity, air leaks inwards. It is particularly important that the part of the system inside the building is under negative pressure.

6.11 If the siting of the fan near the discharge point cannot be achieved, then it is essential that the number of joints in any ductwork that unavoidably passes through voids or other unventilated spaces be kept to an absolute minimum.

Damper

6.12 To achieve the required face velocity, each fume cupboard should be fitted with an air flow control device or damper.

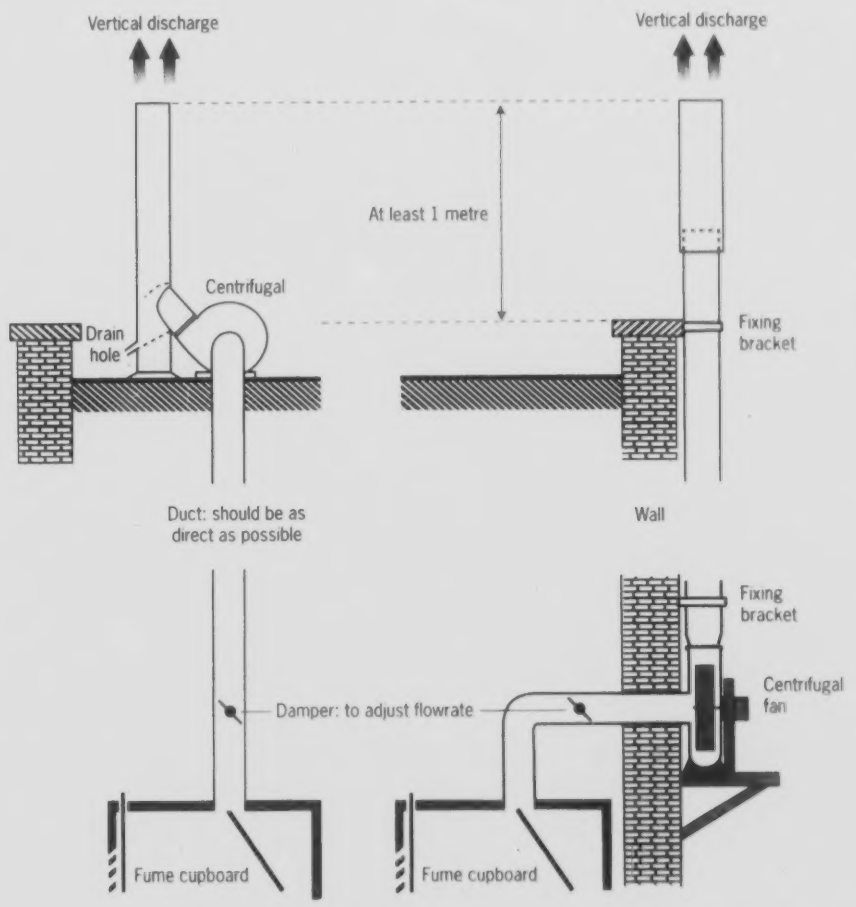
6.13 Where the damper control is in an easily accessible position, it must be fitted with some locking device to prevent unauthorised interference.

6.14 While a damper should be fitted, it should not be required to do more than make small adjustments to the air flow. Fitting an over-powerful fan and using the damper to reduce the air flow to an acceptable level is a waste of money and likely to increase noise near the fume cupboard.

6.15 If the 14-monthly monitoring required by COSHH is to be valid, it is essential that the damper setting can be locked or at least require a tool to change it.

Figure 6.2

Two modern extraction systems



Make-up air

6.16 If the air flow through the face of the fume cupboard is to be satisfactory, there must be adequate provision for make-up air, that is for air to enter the room to replace that extracted by the fume cupboard and by other devices also extracting.

6.17 It is important that the flow through a fume cupboard is not significantly affected by other fume cupboards and extraction fans, either through some switching arrangement or because of a lack of make-up air.

6.18 Sometimes, perhaps because there is inadequate make-up air, systems are electrically connected so that general ventilation and fume cupboard extraction cannot function simultaneously. This is not satisfactory and can lead to gases being drawn out of the fume cupboard when it is switched off and the general ventilation switched on.

6.19 When a fume cupboard is running, it makes a significant contribution to the ventilation of the room. In a modern building, window frames can be much better sealed than in the past so that they can no longer be regarded as providing make-up air. The air entering through the gaps around two doors is probably sufficient for one fume cupboard. If a room is fitted with several fume cupboards and with extraction fans, the performance of all these devices will be adversely affected unless there are vents or grilles kept permanently open which allow air to enter. The risk of hazardous gases released in a fume cupboard escaping into the room is increased greatly if make-up air is inadequate.

Noise

6.20 The noise level generated in a teaching room by a fume cupboard and its extraction system should not exceed 65 dBA measured at a point 300mm from the face of the fume cupboard and at a height of 1500mm above floor level. Installers should aim for 60 dBA or less.

6.21 A noisy fume cupboard is hazardous. It must be realised that pupils working in a fume cupboard or watching a demonstration in one frequently have to be able to listen to a teacher speaking. If a fume cupboard is noisy, there is a strong temptation to switch it off which can be hazardous.

6.22 Axial fans mounted just above the fume cupboard are usually noisy. These should be fitted only for upgradings where other fans are impracticable.

Ductwork

6.23 The cross-section should be circular. The diameter should be chosen so that the air velocity in the duct passing through any teaching room does not exceed $5ms^{-1}$. Higher velocities increase noise levels and require greater fan power.

6.24 The route followed by ductwork should be as direct as possible, with horizontal runs kept to a minimum. These should have no adverse falls where condensate might collect. Bends and offsets should have the largest possible radii. Silencers, fire dampers and guide vanes should be avoided unless absolutely essential. The number of joints in ductwork that unavoidably passes through voids or other unventilated spaces must be kept to an absolute minimum.

6.25 The materials of construction of ductwork, both ducting and seals, should be resistant to the gases they are likely to come in contact with including vapours of solvents. Rigid PVC is satisfactory. It should meet the requirements for the 'self-extinguishing' and 'very low flammability' classifications of BS 2782 test methods 140E and D and also the 'very low flame spread' classification of BS 476 Part 7 for Class 1 materials.[2]

Reference

[2] BS 2782: Part 1: Method 140E 1992 *Determination of the burning behaviour of horizontal and vertical specimens in contact with small flame ignition source* and Method D 1980, confirmed 1987, *Flammability of a test piece 550mm x 35mm of thin polyvinyl sheeting (laboratory method)*; BS 476 Part 7 1987 (confirmed 1993) *Method for classification of the surface spread of flame of products*; from British Standards Office, 389 Chiswick High Road, London, W4 4AL.

Supports and joints

6.26 Ductwork, both horizontal and vertical, should be adequately supported but supports must allow thermal movement. Flexible joints should be provided where necessary to accommodate this and to reduce transmission of fan vibrations. If a duct is under negative pressure and its diameter is less than 500mm, socket and spigot joints with an appropriate sealant are satisfactory.

Fire

6.27 The passage of ductwork through walls and floors should not be allowed to reduce the fire compartmentation of the building. Fire dampers should be avoided and protection obtained by compartmentation of the ductwork or by running it outside the building. Where fire dampers cannot be avoided, they should be of a suitable corrosion-resistant design with damper blades clear of the air flow and should be accessible for maintenance and replacement.

The fan

6.28 All parts of any fan in the airstream should be resistant to the gases which may be there.

6.29 While it is unlikely that a fan manufacturer would be prepared to guarantee resistance to every chemical, a claim that a fan is 'acid proof' is very likely to be adequate.

6.30 Centrifugal fans using either backward-curved or forward-curved blades should be used. Directly-coupled ones, correctly sized, are most satisfactory.

6.31 Belt-driven fans have the advantage that their speeds are adjustable but they are very unlikely to receive the maintenance which they require and so should not normally be used.

6.32 For quiet operation, outlet velocities should be between $5.5ms^{-1}$ and $7.5ms^{-1}$ and impeller tip speeds in the range $10ms^{-1}$ to $15ms^{-1}$.

6.33 Axial and bifurcated fans are not suitable; they are noisy, particularly if situated close to the fume cupboard, and the air flow through them is more affected by sash height changes. They should be used only for upgrading or if it is impossible to fit a centrifugal fan.

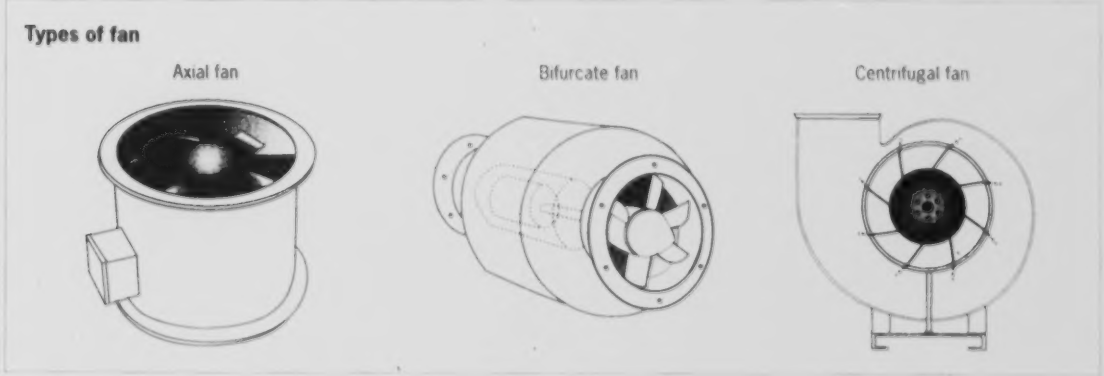
6.34 If an axial fan has to be fitted, it must be a model whose design ensures that sparks cannot be transmitted to the airstream.

Fan mounting

6.35 Care should be taken to ensure that vibrations are not transmitted from the fan to the building or to the duct; anti-vibration mountings should be used.

6.36 Fans must be accessible for cleaning and provision should be made to pipe away any condensate or rain collecting in the fan scroll.

Figure 6.3
The centrifugal fan is the recommended type of fan



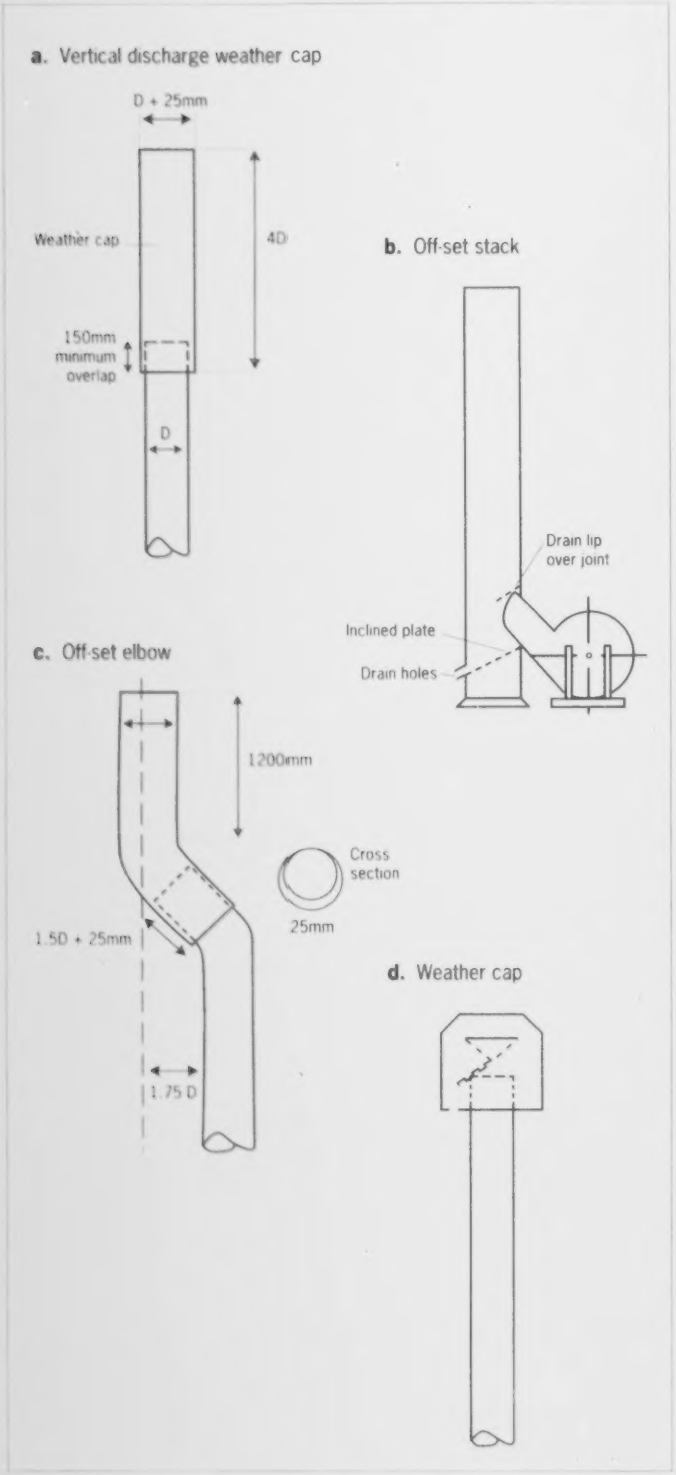


Figure 6.4
Vertical discharge stacks with rain protection

Fan wiring

6.37 If the fan is protected by an RCD, this should not protect other devices or socket outlets (see paragraph 4.35). The fan motor should be protected with a thermal overload device.

Control

6.38 An on-off switch, fitted with an indicator lamp, sited close to the fume cupboard, should be used, not a manual speed regulator which would make it impossible to be sure that the face velocity is maintained at its optimum value: ie, above the minimum (see paragraphs 4.5-4.7) but not so high that Bunsen burner flames are affected.

Fume discharge

6.39 Fumes should be discharged in a vertical direction. The discharge velocity must be at least $5ms^{-1}$. Ideally, the point of discharge should be at a height of 1.25 x the height of the building or 3m above the highest point of the building, whichever is the higher. Where this is not practicable, designers should use their discretion: discharge must be as high as possible and the siting of the discharge stack relative to building protrusions and neighbouring buildings is critical.

6.40 In any event the point of discharge should be a minimum of 1m above the highest point of the building. This avoids the effects on fume cupboard performance of wind variation and eddies, eg, at the edge of parapet roofs. An additional advantage of having the discharge at least 1m above the highest point is that it is much less likely to become obstructed by footballs, vegetation, etc.

6.41 The discharge stack must be sited so that prevailing winds, natural down-draughts, eddies caused by building protrusions, etc, do not cause the entrainment of fumes in any fresh air entering the building, or other buildings.

6.42 Attention must be paid to the position of windows and ventilation inlets, particularly any on higher buildings close to the laboratory building and also to any air inlets on the roof on which the stack is mounted.

6.43 Arrangements to prevent significant quantities of rain passing into the system when the fan is not functioning are shown in Figure 6.4. Any remaining small quantities which reach a centrifugal fan will pass out through a drain hole in the scroll.

6.44 In the rare cases when an axial fan or a bifurcated fan has to be fitted, then measures need to be taken to prevent any rain entering the fume cupboard. Arrangement (a) in Figure 6.4 has been found to let in small quantities of rain. Arrangement (c) should be suitable or the specially-designed weather cap shown in (d). Several weather caps, designed to impede vertical discharge as little as possible, are available. The example, illustrated in Figure 6.4(d) is the 'Clearflo' fume discharge from Plade, Gladstone Avenue, Barrhead, Glasgow, G78 1QT. A 'coolie hat' as shown in figure 6.1 should not be fitted as it reduces dispersion and increases the effect of wind on performance.

6.45 Any gauze or grid fitted over the end of the stack must have a wide mesh. This prevents birds, etc, entering the system but does not become significantly clogged with dust.

Section 7: Commissioning and monitoring fume cupboard systems

Ideally, the supply and installation of any fume cupboard should be carried out by the same company; if two or more contractors are involved, it is often difficult to decide which is responsible for a particular task. If more than one contractor is involved, it is important to define the responsibilities of each; the commissioning schedules in Appendix C may be useful for this. As the recommendations in this bulletin allow the customer choice in a number of matters, a clear agreement should be reached and recorded before work begins.

Commissioning and monitoring

7.1 The instructions for commissioning and for different types of monitoring are clarified in this subsection. The measurements and observations required for monitoring are also needed for commissioning.

7.2 Two types of monitoring are required for fume cupboards, initial and routine monitoring.

7.3 To aid purchasers, commissioning schedules covering all types of fume cupboard are given in Appendix C. However, purchasers should carry out their own initial monitoring before accepting a newly-installed fume cupboard; it is unwise to accept the installer's data.

Initial monitoring

7.4 This is needed to see whether a fume cupboard is adequate and should be carried out before a fume cupboard is commissioned or upgraded or when, for some other reason, there is no data on the fume cupboard.

New fume cupboards

7.5 The filter(s) in a new filter-type cupboard should be tested to ensure proper seating and effective sealing; they should also be tested every time a filter is inserted.

7.6 Relevant to the initial monitoring for a new fume cupboard are:

	Appendix
schedules	C
instructions for face velocity measurements	B2
record form for initial face velocity measurements and filter saturation	B3
instructions for filter saturation testing of fume cupboards	B4

Existing fume cupboards

7.7 To be safe to use, these should conform to the minimum face velocity at an adequate sash height; requirement given in Appendix B2. They need to conform to a few other requirements of Appendix B but it is desirable if they are upgraded to meet the specifications for new fume cupboards given in Section 4. Filter fume cupboards should conform to Table 4.1.

7.8 Relevant to the initial monitoring for an existing fume cupboard are:

	Appendix
instructions and a report form for a visual examination	B1
instructions for face velocity measurements	B2
record form for initial face velocity measurements and filter saturation	B3
instructions for filter saturation testing of fume cupboards	B4

Routine 14-monthly monitoring required by the COSHH Regulations

7.9 The 14-monthly visual examination can be regarded as a shortened version of the initial examination: ie, materials of work surfaces, the existence of stops, etc, will not change. However, the condition of certain items still needs a thorough assessment: the work surface and linings if asbestos-cement; the sash mechanism; service fittings; the fan; the ducting; and the duct exit. See Appendix B1.

7.10 Also, the face velocity must be monitored, as a drop in face velocity will reduce containment and perhaps be a symptom of an obstruction in the duct which may worsen, or of the fan motor starting to fail, etc. (see Apppendix B2).

7.11 The filter(s) in a filter-type cupboard should be tested for saturation with an acid gas (see Apppendix B4).

7.12 Relevant to the 14-monthly monitoring are:

	Appendix
instructions and a report form for a visual examination	B1
instructions for face velocity measurements (no need to calculate the variations)	B2
instructions for filter saturation testing of fume cupboards	B4
record form for 14-monthly face velocity, filter saturation and visual examination	B5

The 14-monthly period specified suggests annual monitoring with two months grace (see paragraph 1.11).

Who can conduct monitoring?

See paragraph 1.12

Equipment for measuring air flow

Air flow meters which are suitable

7.13 There are many air flow meters, sometimes called anemometers, on the market but not all are suitable for school fume cupboards. The main problem is finding a meter sufficiently accurate around 0.3ms^{-1} but at a reasonable price. The turbulence of the air flow expected for school fume cupboards can cause divergence between the readings of different types of meter.

Accuracy and corrections

7.14 The meter should have an uncertainty of about 10% or less around 0.3ms^{-1}. Users may have to apply corrections from a calibration certificate from the supplier. Some suppliers will provide a certificate at a reduced price if readings are confined to a limited range of, say, 0.2 to 1ms^{-1}.

Averaging over a period

7.15 The main problem with face velocity measurement of small fume cupboard systems is trying to take readings while the face velocity is fluctuating due to wind changes. Therefore, a facility which automatically averages over time is valuable.

Type of meter

7.16 It is important that the meters used for type-testing and commissioning school-type fume cupboards give readings consistent with those obtained during the 14-monthly tests. A unidirectional hot-wire meter with a facility for averaging readings over a period of time is ideal but costs over £600. A properly maintained rotational-vane meter gives readings consistent with unidirectional hot-wire meters but has the advantage that, even with a facility for averaging readings over a period of time, can be purchased for less than £300. Its disadvantages are that it requires more frequent calibration and is more easily damaged. Omnidirectional hot-wire meters tend to give higher readings than the other meters; if used, a correction should be applied.

Conclusion on choice of meter

7.17 If a unidirectional hot-wire air flow meter with a facility for averaging readings over periods of 10 seconds or more cannot be afforded, a rotating-vane air flow meter with vane diameter between 60 and 100mm and the same averaging facility is suggested.

How often is recalibration necessary?

7.18 Much depends on how frequently an air flow meter is used and how well it is treated. Recalibration will be needed more frequently with rotating-vane meters because these have mechanical parts; once every three or four years is likely to be needed for a meter owned by a school and brought out only once a year to monitor a few fume cupboards. However, should unexpected results be obtained, eg, all the fume cupboards appear to give significantly higher or lower readings, then there may be a need for recalibration. Another factor influencing the frequency of recalibration is whether any fume cupboard has a face velocity close to the borderline.

Smoke tests

Ways of generating smoke

7.19 Smoke can be produced easily by three methods: from a smoke 'pencil' (also called an air-current tube), from a smoke pellet or from a smoke match.[1] A smoke pencil is a sealed glass tube, about 100mm long, containing sulphuric acid (corrosive) supported on a porous matrix. When the ends are broken off, the tube fitted into a rubber bulb and air puffed through, a mist consisting of droplets of sulphuric acid is produced. The quantity of mist depends on the humidity of the atmosphere but can be controlled by the extent the bulb is pressed. The bulb and partially-used tubes should not be kept near equipment such as an air flow meter. The smoke is corrosive and should be used with care and directed away from the user.

7.20 Smoke pellets are ignited and for about a minute produce smoke which is not toxic but irritating to the eyes and respiratory system. A pellet generates smoke at about 0.25 m^3s^{-1} and so can easily overwhelm a school fume cupboard, which will have a volume air flow of about 0.16 m^3s^{-1}. Smoke matches are similar to pellets but last for about 20 seconds, producing smoke at about 0.1 m^3s^{-1}.

7.21 Smoke can be used for several purposes.

General direction of flow

7.22 It is not uncommon for fan motors to be wired the wrong way round; if axial, this will result in air being blown outwards and this will not be detected by most air flow meters which are non-directional. A smoke test can be used to confirm the direction of flow. However, smoke is not the simplest method of showing the flow direction: firmly holding up a narrow strip of one ply of a paper tissue in the working aperture is just as effective. A smoke pellet would be unsuitable because, if the flow were out from the fume cupboard, the room would fill with smoke.

Testing the integrity of the ducting, etc

7.23 If a leak is suspected in a duct, a smoke pellet can be ignited to produce large quantities of smoke. This may then be seen or smelt escaping from a poorly-sealed joint, etc.

Reference

[1] Air current tubes obtainable from Draeger Ltd, Ullswater Close, Kitty Brewster Industrial Estate, Blyth, NE24 4RG; smoke pellets and matches from PH Smoke Products Ltd, Unit C5, Baird Court, Park Farm Industrial Estate, Wellingborough, Northants, NN8 3QH.

Problems with fumes after discharge

7.24 A smoke pellet can be used and the smoke observed as it leaves the duct. Clearly, it is wise to choose a time when, if smoke does re-enter the building through a window, air inlet etc, no one is inconvenienced.

The containment of a fume cupboard

7.25 For checking containment, smoke must be used with extreme caution. Fume cupboards do not contain perfectly: small escapes near the edges of the working aperture must be expected (See Appendix A).

7.26 A smoke pencil can be used to compare the containment of two fume cupboards. It should be held at various points around the working apertures and the trails of smoke observed. Results must be interpreted with caution as slight changes in position of the pencil may produce significant changes in effects which may also change with time. Any attempt to compare two fume cupboards will depend on their siting because the behaviour of the smoke will be affected by draughts in the room. Much depends on experience but it must be realised that it is not difficult for someone experienced in using smoke tests to make the containment of one fume cupboard look high and that of another low.

7.27 It is not advisable to use smoke pellets to demonstrate the containment of fume cupboards. The rate of generation of smoke exceeds the volume air flow through the fume cupboard and will significantly alter the normal flow patterns within the fume cupboard. If it is suspected that gases are escaping through the bypass, etc, a smoke pencil or smoke match should be held inside the fume cupboard.

A fume cupboard log book

7.28 Users and those responsible for the maintenance of a fume cupboard may find it useful to assemble a log book, whose contents may include:

- the telephone and FAX numbers and the addresses of the supplier, installer, maintenance contractor, and the supplier of any test equipment, etc;
- the supplier's literature and the commissioning data (perhaps based on Appendix C), if available;
- initial data determined by the school or a contractor, as in Appendices B1 to B4;
- annual test records, as in Appendix B5;
- annual test record forms and instructions for completing them.

Section 8: Repairing and upgrading existing fume cupboards

8.1 Some faults in fume cupboards can be put right by the users themselves. Even if technical help is needed, much time can be saved if those reporting fume cupboard failures give a reasonably accurate description of what is wrong. There is a tendency to 'call in the experts', not realising how expensive this can be; it is better to have some idea first of what the problem is.

8.2 If a fault cannot be put right by the user, it often only needs the attention of an electrician or gas fitter; however, the employer then has an extra responsibility to ensure that work carried out conforms to the recommendations of this bulletin. More complicated faults require a fume cupboard specialist.

8.3 Electrical faults such as blowing of fuses or operation of cut-outs indicate faults needing investigation. For this, it will be less expensive to call in a local electrician than a fume cupboard specialist.

8.4 Some faults will appear as a result of testing in accordance with Appendix B.

8.5 It may be cheaper to replace a fume cupboard than to carry out extensive upgrading on an old model. Each case has to be decided on its merits.

8.6 It is very important that any electrical testing or repair is done by a competent person, eg, a qualified electrician; similarly, any repairs to the gas system should be made by a registered fitter.

Ducted fume cupboards

Reasons for failure

8.7 The main reasons why a fume cupboard fails to operate or should not be used are the following:

a. the fan does not rotate;

b. the fan blows the wrong way;

c. the face velocity is below 0.3ms^{-1} with the sash set so that the working aperture is 400mm high;

d. fumes escape from the system at concentrations which cause concern;

e. the sash cords or cables or the sash spring mechanism are broken so that the sash cannot be opened, or the sash cords or cables are such that failure is imminent;

f. asbestos-cement is found as the work surface material or as a lining material and is flaking;

g. the fume cupboard has two sashes in different rooms;

h. the services, the gas supply in particular, are damaged to the extent of causing a hazard.

Reasons for upgrading

8.8 Sometimes testers point out defects which are less serious. They are not reasons for prohibiting use of the fume cupboard but they should be remedied as soon as possible.

8.9 They include the following:

i. the variation in face velocity exceeds ±30%;

j. asbestos-cement is identified in the work surface or lining material but is not producing any dust;

k. the glazing is not safety glazing;

l. the maximum sash height is defined by a label, not by a stop;

m. there is no stop to prevent the fume cupboard being completely closed;

n. the work surface is not dished and there is no lip at the front.

Fan failure

8.10 This can be detected if the noise of the fan cannot be heard and/or if a narrow strip of tissue held firmly in the working aperture is not pulled into the fume cupboard as is normally the case.

8.11 The fan motor may be broken or the fan may have come loose on its shaft or the drive belt may be slipping.

8.12 A local electrical repairer or ventilation contractor may be able to repair or replace fan motors more cheaply than a fume cupboard specialist. However there is a danger that a fan or motor of the wrong size could be fitted.

8.13 An axial fan blowing the wrong way, perhaps as a result of faulty reconnection after servicing, can be detected by firmly holding a narrow strip of tissue in the working aperture. A local electrician should be able to reverse connections to the fan motor which is all that is needed to reverse the direction of the fan.

Inadequate face velocity

8.14 This will be detected during the initial or 14-monthly monitoring when face velocity measurements have to be made (Appendices B3 and B5). It is important to distinguish between the situation when a face velocity is judged to be too low because the system is basically inadequate and the situation when the face velocity appears to have fallen since the last measurement or since installation.

8.15 Absence of proper records can sometimes make it difficult to distinguish between the situations.

A fume cupboard whose face velocity has always been inadequate

8.16 There is a good chance that fume cupboards installed before 1980 will have inadequate air flows, even if working to the designers' specifications. If the ventilation is provided by an axial fan sited just above the fume cupboard and if the ducting is small (150mm in diameter), the face velocity is likely to be too low. It will usually be necessary to replace the extraction system completely, particularly if the ducting is only 150mm in diameter.

8.17 However there are some points which should be checked before an old cupboard is dismissed as inadequate:

- Any damper (see paragraphs 6.12-6.15) in the system may have been closed too much.
- The fan is not vibrating excessively. This could probably be remedied by a local ventilation engineer.
- Paper or plastic sheet has been sucked into the duct. (Take steps to prevent the fan being switched on while removing any obstruction.)
- The discharge point has been blocked by bird's nests, footballs or vegetation. The cautious use of smoke may be useful here (see paragraphs 7.23). If access is difficult, worthwhile observations can sometimes be made from a distance with binoculars.
- Any centrifugal fan is rotating the right way. If it is rotating the wrong way, it will produce a much diminished air flow. This possibility should be suggested to a local electrician.

8.18 If there are two fume cupboards using the same fan, it is sometimes possible to obtain one fume cupboard with adequate face velocity by blocking off the ducting at the top of one of the fume cupboards. Similarly, if a fume cupboard has two sashes in the same room, an adequate face velocity may be obtained under one sash if the other is permanently screwed down.

8.19 If a fume cupboard has a face velocity which just falls below $0.3ms^{-1}$ when the height of the working aperture is 400mm, then it could be used temporarily with the aperture height kept below a limit less than 400mm, although a height less than 300mm is not recommended in any circumstances. Risk assessments should be made of any operations likely to become unsafe because of the effect of the restricted aperture on manipulations; some may have to be abandoned. However, in some operations which require the full 400mm, such as pouring 2-litre bottles of concentrated acids, the amount of hazardous vapour released is so small that it would probably be judged to be safe to open the sash to the maximum.

When the face velocity has fallen

8.20 When it appears that a previously adequate face velocity no longer is, it is worth checking the following:

- The sash height is the same as for previous measurements.
- Any damper, particularly a readily accessible one, has not been re-adjusted.
- Any speed control has not been re-adjusted.
- The air flow meter is reading correctly. For the reasons given in paragraphs 7.13-7.18, different types of meter can give different readings and meters need re-calibrating from time to time.
- Conditions are not different. For example, strong winds from different directions may affect readings, as may whether doors and windows in the room or even the building are open or shut. Particularly relevant would be the installation of another fume cupboard or an extractor fan.
- The fan is not vibrating excessively. This could probably be remedied by a local ventilation engineer.
- No paper or plastic sheet has been sucked into the duct. (Take steps to prevent the fan being switched on while removing any obstruction.)
- The discharge point has not been blocked (see paragraph 8.17).

Escaping fumes or Variation exceeds +/-30%

8.21 Smoke may be useful in confirming and clarifying problems of escaping fumes. (see paragraph 7.23)

8.22 Minor escapes from the working aperture must be expected. However, if the variation is greater than ±30%, (Appendix B2), escapes may present a hazard.

8.23 Sometimes the situation can be improved by reducing draughts across the front of the fume cupboard, perhaps by keeping certain windows and doors shut. If this cannot be done, it may be worth consulting a fume cupboard specialist. It may be possible to fit a baffle to the fume cupboard or re-locate the duct exit.

8.24 Leaks elsewhere in the system may be prevented by sealing or re-bonding joints. Laboratory staff or a local ventilation engineer may be able to do this.

Re-entry of fumes

8.25 The re-entry of fumes into the building suggests failure to fit a high enough stack with vertical discharge or poor siting of the discharge stack. However, it is worth checking that it is not due to partial blockage of the discharge point perhaps by releasing smoke in the fume cupboard (see paragraph 7.24). It is sometimes possible to reduce re-entry through inlets, of a certain type, on the same roof by rotating their cowls away from the discharge stack. However, it is probably necessary to consult a ventilation specialist.

Sash mechanisms

8.26 Some sashes are supported by cords or cables leading to one or more counter-weights. A local carpenter who can repair sash windows should have no problem in replacing broken cords. If only one has broken, it is usually cost effective to ask for both to be replaced. Such a carpenter may not have a supply of stainless steel cable but should be asked to find and use it.

8.27 Some sashes are supported by springs. If this is the case, the plastic tube surrounding the spring can usually be seen at the top of the slots in which the sash frame slides. Another indication of support by springs is a tendency for the sash not to remain exactly where placed by the user. If the springs fail, a fume cupboard specialist should be consulted.

8.28 The sash should never be obscured by being used as a poster board.

Asbestos-cement work surfaces or linings

8.29 There is no legislation prohibiting the use of asbestos-cement as a material for the work surfaces but its use is not advised at the present time. The Regulations[1] specify a level of asbestos in the air which should not be exceeded[2]: 0.5 fibres per cm^3. It is difficult to see how this figure could be reached in the air breathed by any person from any asbestos-cement within a fume cupboard unless it was crumbling badly. Further advice is available from the Department of the Environment and in the Department for Education and Employment's Memorandum.[3]

8.30 However, if an employer has a policy of removing all asbestos products, this must be respected. If this is not the case, asbestos-cement surfaces can often be sealed. Covering the work surface with a melamine laminate is a possibility but, because it would need to be fitted round gas and water outlets etc, it is sometimes no more difficult to remove the asbestos-cement and fit a completely new surface. A 12mm solid grade laminate is suitable for the work surface lining and a grey speckled finish is preferable to plain white to tone down any burn marks through the face of the laminate.

8.31 Asbestos sheet side linings can be replaced with solid grade white faced laminate.

8.32 Sealing the surfaces to prevent the emission of dust is also a possibility. Chemical-resistant paint is the best seal but, typically, one coat each of three different paints is required which is expensive unless several fume cupboards need treatment. Emulsion paint used for normal decoration may be more practicable, as it is inexpensive and will withstand the slight alkalinity of the asbestos-cement better than ordinary oil-based paint. The work surface will need protection with heat-proof mats but these are readily available in school laboratories.

Fume cupboards with sashes in different rooms

8.33 The reasons why the traditional arrangement of a fume cupboard shared between a laboratory and a preparation room is hazardous are given in paragraphs 4.69 and 4.70. It is best if one side is sealed completely, any stops which prevent complete closure being removed first. If this is impossible, then both sides could be used, one at a time, provided:

- there are no bypasses (secondary air inlets);
- both sides can be closed completely, preferably with locks or, at least, bolts;
- there are parallel operating switches so that the fume cupboard cannot be switched off in one room while being used in the other;
- there are labels stipulating that only one side should be used at a time, with the other side locked down.

Glazing is not safety glazing

8.34 As a temporary measure, a safety film can be applied to the outside of the glass. To achieve a satisfactory result, the glass needs to be cleaned very thoroughly before the film is applied and care taken to avoid bubbles of air trapped between the film and the glass. After some years the film will become scratched during cleaning and possibly rendered less transparent by the gases present.

8.35 **Suitable film can be bought from specialist suppliers but a more practicable source for those requiring only a small quantity may be a specialist child-care shop, eg, Mothercare.**

8.36 Replacement of ordinary glass with a safety glass such as toughened glass is a good long term solution but it is not easy. In particular, the sash will almost certainly need rebalancing with a new counter-weight fitted.

References

[1] *The Control of Asbestos at Work Regulations, 1987*, HMSO, ISBN 0 11 078 1155.

[2] Also quoted in EH40; see Reference 3 in Section 1.

[3] *Asbestos Materials in Buildings*, third edition 1991, Department of the Environment, London: HMSO, £4.80, ISBN 0 11 752370 4, and *Administrative Memorandum 3/86*, (Department for Education and Science), *The use of asbestos in educational establishments*, available from the DfEE.

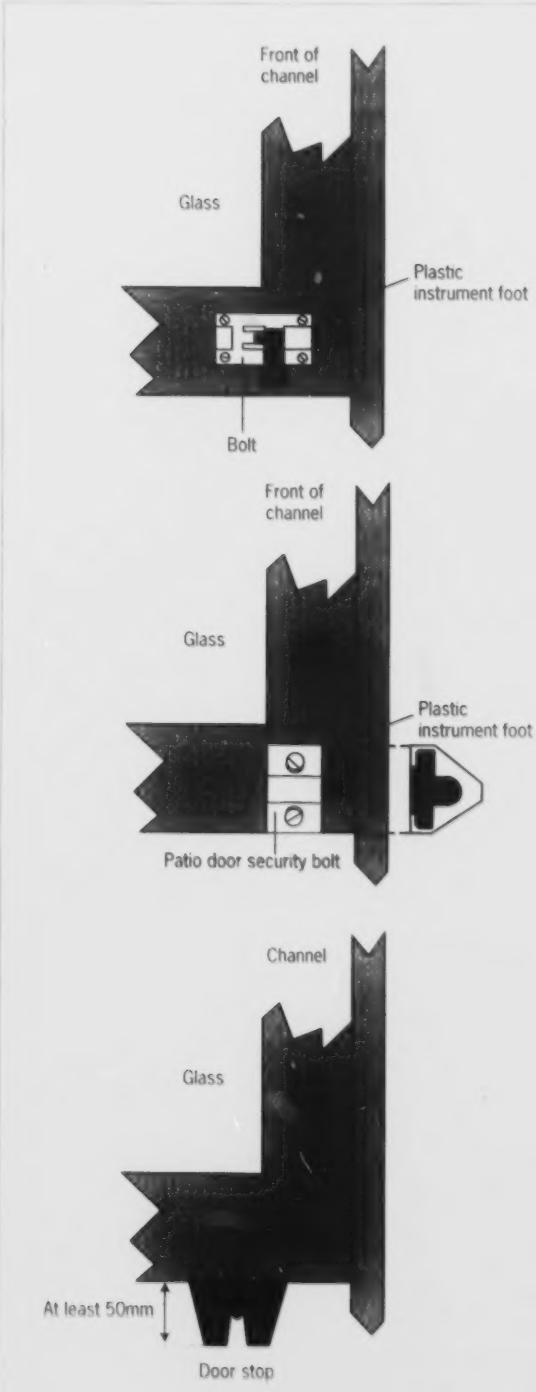


Figure 8.1
Fitting stops to wooden-framed cupboards

Gas controls

8.37 Many of the yellow gas knobs on the front of cupboards have no visible marking to indicate against the 'ON' 'OFF' marks on the facia. One solution is to produce a black mark by drilling the knob and filling it with paint.

No maximum safety stop

8.38 It is useful to fit stops, one on each side, which limit the highest position of the sash; labels can be ignored. It is preferable to fit a pattern which can be unlocked to allow the sash to be raised higher for cleaning or assembling tall apparatus.

8.39 It is easy to fit a suitable stop on fume cupboards made of wood. Figure 8.1 shows a small bolt and a patio door spring-loaded security bolt being used for this purpose; the patio door lock has the advantage of requiring a key to unlock it. The lock and the bolt are both fitted to the sash frame and a plastic buffer, an instrument foot, fitted to the edge of the channel in which the sash slides. The bolt and the patio door lock can be purchased from hardware or DIY outlets, the instrument foot from an electronic components supplier.

Stop to prevent complete closure

8.40 Two large plastic door stops can be fitted to the underside of the sash frame, one at each side (See Figure 8.1).

Front lip

8.41 If the work surface has no means of retaining spillages, a strip eg, hardwood or plastic, can be attached across the front of the fume cupboard. It should then be sealed all round the inside edges with a sealer such as silicone rubber mastic.

BEST COPY AVAILABLE

Filter fume cupboards

8.42 There are fewer filter fume cupboards than ducted ones in schools. As it is unlikely that technicians from the supplier will be able to combine their visit with one to other schools in the area, call-out, monitoring and service charges may be high. Again as for fixed fume cupboards, suppliers are often called in for trivial faults which could have been dealt with by a local electrician. However, handbooks are supplied with filter fume cupboards. If these are read and understood, several problems which may arise with filter fume cupboards can be put right. Also it might be worth telephoning the supplier for further advice.

Fall in face velocity

8.43 A fall from previous readings may be found during the 14-monthly monitoring (Appendix B5). Alternatively, it may be indicated by a warning light on some models. It may be due to the pre-filter becoming blocked with dust. Pre-filters are relatively inexpensive and should be replaced (see paragraph 4.63) and the face velocity tested again.

Release of hazardous gases, smells, etc.

8.44 If a hazardous gas can be smelt, this does not mean that the fume cupboard is failing. As has been explained (see paragraph 4.60), a filter cannot be 100% efficient and the nose is very sensitive. What is smelt may be the small quantity of gas which must pass through and which will present no hazard when dispersed in a normal-sized laboratory with adequate natural ventilation.

8.45 However, if the smell is excessive, it is worth carrying out a filter saturation test (Appendix B4). If this indicates that the filter efficiency is unacceptably low, it can be for the following reasons:

a. The filter is not properly seated. It should be taken out, the seal, which is like a strip of draught excluder, checked for deformation and the filter carefully replaced. The test should be repeated.

b. The active carbon granules do not cover the cells in the filter evenly. This can happen if the filter is stood on end during delivery or storage. The granules can be redistributed by holding the filter horizontal and knocking it gently.

c. The filter has become saturated and needs replacement.

Minor component failures

8.46 There are reports of hinges and other components breaking or showing signs of corrosion, particularly those in early models. Legislation[4] requires that goods are suitable for the purpose for which they were sold and equipment sold for school laboratories should stand up to both pupils and fumes. If suppliers are reluctant to replace components free of charge, it might be helpful to remind them of this statutory duty, at least during the first year or two of use.

Maintenance

8.47 The handbooks supplied with filter fume cupboards detail any maintenance required. This should be carried out. In particular, any checking of the settings of low-flow indicators, etc, must be done.

Disposal of filters

8.48 Saturated filters should be securely wrapped in two layers of polythene, ie, put inside two bin liners, sealed with parcel tape and placed in the refuse.

Reference
[4] Sale of Goods Act 1997, HMSO, ISBN 0 10 545 4796

Appendix A: How a fume cupboard works

A1 General principles

A fume cupboard is intended to prevent hazardous dusts, gases or vapours being inhaled. A subsidiary function can be to act as a safety screen to protect persons from explosions, splashes etc.

Protection is achieved by a flow of air which first draws the gases away from the breathing zones of the user and others. Secondly, the air flow dilutes the hazardous gases. Typically, the maximum rate at which a hazardous gas is generated is less than 50 $cm^3 s^{-1}$ (cubic centimetres per second) while the air diluting it passes through the fume cupboard at about 0.15 $m^3 s^{-1}$ (cubic metres per second), ie. 150 000 $cm^3 s^{-1}$. Thus a dilution approaching three thousand is achieved, assuming perfect mixing.

The diluted gas, even with only partial mixing, is already safer than the undiluted gas, because, if it were inhaled, a very much lower mass of it would enter the body. However, safety is further increased by following dilution either with dispersion into the atmosphere outside the classroom or absorption into a filter.

To achieve safe dispersion into the atmosphere, the diluted gas is ducted to a high point where it is released through a properly designed and sited discharge stack. (see paragraphs 6.39-6.45) Fume cupboards which function in this way are referred to as 'ducted fume cupboards'.

Absorption into a filter is becoming increasingly popular because filter systems are easier and cheaper to install. Fume cupboards which function in this way are referred to as 'filter fume cupboards'.

A2 The effectiveness of fume cupboards

Fumes escaping

Eddies can carry some of the gases out of the fume cupboard and most commonly occur close to edges, eg, to the sides of the working aperture. Even if a fume cupboard has aerodynamically-shaped surfaces, some escapes must be expected. However, research[1] has shown that, with the low releases of gases during school use, the exposure levels resulting from fume cupboards meeting the recommendations on air flow in this Building Bulletin are well below exposure limits.

More substantial escapes of gases can occur as a result of arm movements of the user, of someone moving in front of the fume cupboard or of rapid sash movement. Draughts across the front of a fume cupboard also can cause escapes which is why the siting of fume cupboards is important (Section 5).

Discharged fumes

A ducted fume cupboard can put persons at risk if the fumes from the discharge point are blown or drift into areas occupied by people, eg, if they fall close to the ground, enter windows or are sucked into ventilation systems. The design and siting of stacks from fume cupboard systems is critical (see paragraphs 6.39-6.45).

Filter failures

A filter fume cupboard can fail if a hazardous gas bypasses the filter or if too high a proportion passes through it. (Inevitably some will pass through the filter which cannot be 100% efficient.) A gas can bypass a filter which is not properly seated and too much can pass through a filter which is inadequate for the flow rate or which has become saturated.

Containment

Containment is a measure of the efficiency of a fume cupboard. A crude measure of the containment of a fume cupboard is given by:

R/C where

R is the rate of release of the hazardous gas inside the fume cupboard, and

C is its concentration just outside the fume cupboard. C can be compared with the exposure levels established by legislation (see paragraph 1.2 and Appendix E) and decisions made as to which operations can be safely performed in the fume cupboard.

Clearly, the bigger the ratio, the more successful the fume cupboard is in protecting persons outside. The recommendations in this bulletin are based on containment tests conducted on school fume cupboards, using values of R measured and estimated for school activities.[1]

Because carrying out containment tests requires relatively sophisticated equipment and is time-consuming, alternative tests are recommended in this bulletin for commissioning and subsequent monitoring. They are tests of minimum face velocity and variation in face velocity.

Smoke tests (see paragraphs 7.25-7.27), carefully used, can give a qualitative indication of any significant containment failures but they should not form part of any contract as their interpretation is too subjective.

Face velocity

This is the velocity of air through the working aperture. It is usually measured at several points over the aperture (Appendix B2). Measurements show that disturbances, eg, movements of the user or cross draughts, reduce containment more if the face velocity is low. On the other hand, higher face velocities can increase turbulence in fume cupboards of simple design and cause Bunsen burner flames to be unstable and even to extinguish. The optimum face velocity is a compromise.

Variation

This is the spread in values of the face velocity measured across the working aperture; the greater this is, the greater the likelihood of significant escapes caused by eddies. A simple measure is the percentage differences of the maximum and minimum values from the average value. (Appendix B2)

Determining effectiveness

To summarise, the effectiveness of a fume cupboard is usually assessed by taking measurements of the face velocity and finding its minimum value and variation. Values of these for school fume cupboards and details of the measurement procedure are given in Appendix B2. In addition, the main filter in a filter fume cupboard should meet certain specifications (Table 4.1).

Reference

[1] The investigations are reported in *'School Fume Cupboards'*, J R Crellin, Education in Chemistry 21 (6), November 1984, pp 185-8.

Appendix B: Monitoring and commissioning and test report forms

Appendix B1: Instructions and report form for a visual examination

Feature	Question	Pass or Fail[1]	P/F	Report
Work surface	*Is there any damage? (If it is made of asbestos-cement, report it, particularly noting if it is dusty or flaking.)*	**Fail** if it could produce significant dust levels in the room. Otherwise, consult the employer. Sealing it is possible.		
Linings	*Is there any damage? (If these are made of asbestos-cement, report them, particularly noting if they are dusty or flaking.)*	**Fail** if they could produce significant dust levels in the room. Otherwise, consult the employer. Sealing it is possible.		
Glazing	*Is there any damage? Is it plastic? (If glass, report if there is no evidence that it is a safety glass: eg, an engraving on the glass or a statement from the supplier of the fume cupboard.)*	Explosions in fume cupboards are very rare so that the presence of ordinary glass is not a reason for failure unless the employer stipulates it. It is possible to cover glass with safety film.		
Sash mechanism	*Does it function satisfactorily? Are there signs of damage to the cables?*	**Fail** only if the sash is likely to descend rapidly.		
Sash limits	*Are there stops to:* *(a) limit the aperture to the correct maximum height?* *(b) prevent it being closed completely?*	While stops should be fitted, labels indicating sash limits are acceptable temporarily. Do not fail unless the employer stipulates it; fix labels.		
Fan	*Is there any sound of excessive vibration?*	**Fail** only if the motor seems likely to fail soon but recommend steps to remedy.		
Electricity, gas, water and drainage services	*Is there any corrosion or damage which make the services unsafe? (Also check the drip cup, trap and drain for signs of leaks, blockage, etc, and the pipes and wires under the fume cupboard).*	**Fail** only if there is a real possibility of a gas leak, of electric shock or a spark from an electric circuit igniting the gas.		
Ducting	*Are there any signs of damage, particularly to seals? Are there any reports of smells along its route?*	**Fail** if there is a significant leak at a point where the pressure inside the duct is above atmospheric.		
Duct exit	*Is there anything which obstructs it or which might eventually obstruct it? (The extent of the inspection will depend on the site of the exit and who is conducting it.)*	**Fail** if the duct is obstructed or about to be obstructed by birds' nests, footballs etc.		

[1] **'Fail'** indicates that it is advisable if use is discontinued forthwith.

Appendix B2: Instructions for measurements of face velocity

Procedure

1. Do not attempt measurements on a windy day. It is best if doors are not being opened and shut elsewhere in the building.
2. Arrange the ventilation of the room so that it is most unfavourable to extraction by the fume cupboard concerned: ie, shut all doors and windows and switch on any other fume cupboards and extraction fans.
3. Remove everything from the fume cupboard so that the air flow is not obstructed by bottles, etc.
4. Do some quick air flow measurements to see if, with the sash at maximum height, the minimum face velocity is likely to be over $0.3ms^{-1}$. Reduce the sash height until it is. It should be greater than 400mm (but the fume cupboard could be used temporarily with it at a lower value as long as it is not less than 300mm; see Section 8). If this is not possible, the fume cupboard fails.
5. Record this sash height.
6. Imagine the face of the fume cupboard divided into nine equal rectangles. Stand as far as practicable from the fume cupboard with the sensing head in the plane of the sash and take air flow readings at approximately the centres of the nine rectangles.

a	b	c
d	e	f
g	h	i

7. Record for each rectangle the approximate average reading over a period of at least ten seconds, applying any correction from the calibration chart. Use the record form in Appendix B3. Fluctuations in wind outside often make this quite difficult and it may be necessary to take a reading which is averaged over a longer period.
8. Look at the table and repeat any reading which seems to be very different from the general pattern. Record the average of this and the previous reading.
9. Most air flow meters are not directional and so it is necessary to carry out an additional test to ensure the air flow is inwards. A narrow strip torn from one ply of a tissue handkerchief and held **firmly** in the aperture is the easiest test. A smoke test is also a possibility, using a smoke pencil or smoke match, **not a smoke pellet** which can overwhelm a school fume cupboard.

Calculation

1. **Minimum face velocity**

Record which of **a, b, c, d, e, f, g, h, i,** is the smallest; ie, record the minimum face velocity.

Is it above or below $0.3ms^{-1}$? If below, the fume cupboard fails.

2. **Variation**

Add **a, b, c, d, e, f, g, h, i,** and divide by 9 to get the average.

Find the biggest and smallest out of **a, b, c, d, e, f, g, h, i.**

Work out: biggest minus average. Divide the answer by the average and multiply by 100 to obtain the upper percentage variation.

Work out: average minus smallest. Divide the answer by the average and multiply by 100 to obtain the lower percentage variation.

Is each of these less than 30% ? If not, the fume cupboard does not meet the recommendations of this bulletin and, if a new installation, should not be accepted.

The variation in favourable conditions should be below ±20%. However, because it is difficult to find ideal sites in many laboratories ±30% has been stipulated.

Appendix B3: Initial face velocity and filter saturation record form

Employer .....

Fume Cupboard Initial Face Velocity and Filter Saturation Record

School/College: .....

Location of fume cupboard/ Identification number: .....

[1]Manufacturer and model: .....

Initial examination carried out by: .....

Date: .....

[2]Wind conditions and approximate direction if significant: .....

Air flow meter used (model and serial number): .....

Date when air flow meter was last calibrated: .....

Height of sash opening: ..... mm

Minimum face velocity: ..... ms^{-1}

Average face velocity: ..... ms^{-1}

Variation:

Upper: ..... %

Lower: ..... %

Have corrections from a calibration chart been applied? *YES* ❒ *NO* ❒

Have any readings, very different from the general pattern, been checked? *YES* ❒ *NO* ❒

If the air flow meter is non-directional, does a second test (narrow strip of tissue, smoke test) confirm that air is flowing into the fume cupboard? *YES* ❒ *NO* ❒

Does the fume cupboard pass Building Bulletin 88 face velocity recommendations? (Minimum face velocity above $0.3ms^{-1}$, variation less than 30% with sash opening 400mm or more?) *YES* ❒ *NO* ❒

If *'NO'*, repeat measurements with the sash set lower. Is it possible to find a sash opening above 300mm which gives a minimum face velocity above $0.3ms^{-1}$? If not, advise that the fume cupboard should ***NOT BE USED***.

If a filter fume cupboard, does it pass a saturation test? [3]*YES* ❒ *NO* ❒

If *'NO'*, advise that the fume cupboard should ***NOT BE USED***.

Signature: ..... Date: .....

References

[1] Omit if these cannot be found easily.

[2] It is better not to take measurements if it is particularly windy.

[3] A test should be carried out on a new fume cupboard to ensure that the filter is properly seated and that its contents have not been displaced in transit.

46

Appendix B4: Instructions for filter saturation testing of filter fume cupboards

Electronic detectors for monitoring filter saturation have not yet been shown to be sufficiently reliable for the range of gases used in school science and over a reasonable time scale; therefore chemical tests are needed. If the 14-monthly monitoring of a filter fume cupboard is carried out by a contractor, it is likely to cost £200 - £300 for one fume cupboard, the price per cupboard falling if a school has several. Training is available for school staff wanting to monitor their own fume cupboards.[1]

Pre-filter

The purpose of this filter is to absorb dust. It is a layer of white wadding through which air passes before reaching the main filter. (see paragraph 4.58). As it becomes clogged, the face velocity reading of the fume cupboard will fall.

Main filter

The purpose of this filter is to absorb hazardous gases (see paragraphs 4.59-4.68).

Frequency of saturation testing

As there are strict limits to the concentrations of hazardous gases in air which can be breathed, it is necessary to test the efficiency of the filter regularly. Further, it is prudent to conduct an initial test to ensure that the filter is seated properly and that its contents have not been displaced in transit. It is advisable to test for this every time the filter is replaced.

What test to carry out

In normal school use, the layer of the filter treated to absorb acid gases will almost certainly saturate first. Therefore, it is advised that the only test needed is one using an acid gas. The trichloroethene test is an alternative test useful for testing filter seating.

The general procedure

This involves releasing a gas, eg, sulphur dioxide, inside the fume cupboard at a known rate and comparing that rate with the concentration of gas in the air coming out of the exhaust. A gas detection kit[2] is used to measure the concentration of the gas emitted in the fume cupboard exhaust.

A gas detection kit consists of a disposable tube used with a special pump which draws a measured volume of air through the tube. The length of the colour change within the tube indicates the concentration of the gas tested.

Tests for saturation by acid gases

B4.1 Method using a canister

This method has ceased to be practicable because canisters of sulphur dioxide are no longer available. It is included because contractors may prefer to use a similar method using small cylinders. Schools may prefer to use the burning sulphur method. (see Appendix B4.2)

The canister providing the sulphur dioxide is weighed before and after some gas has been released inside the fume cupboard for a measured time, enabling the rate of release to be calculated. The rate of flow is set first by observing the gas displacing water in a measuring cylinder. The concentration of sulphur dioxide in the exhaust is measured with a gas detection tube, as described above.

Items required are a gas detection kit, a sulphur dioxide canister (toxic), a balance weighing to 0.1g or less, a stop clock plus the glassware shown in Figure B4.1. Wear eye protection. **Sulphur dioxide is a toxic gas, so do not breathe it in.**

References

[1] The CLEAPSS School Science Service runs courses. See address on page 56.

[2] Equipment can be obtained from either Detectawl Ltd, 2 Cochran Close, Crownhill, Milton Keynes, MK8 0AJ (Gastec) or from Draeger Ltd, Ullswater Close, Kitty Brewster Industrial Estate, Blyth, NE24 4RG.

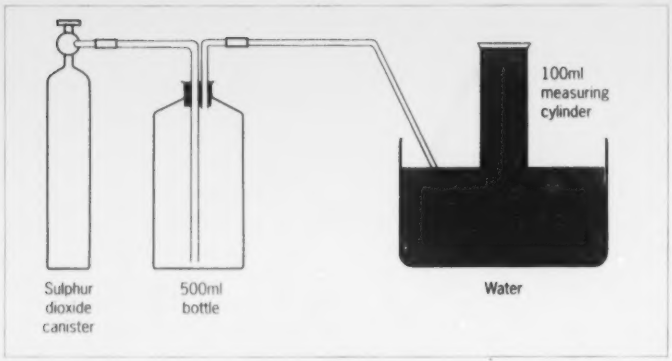


Figure B4.1
Setting the rate of flow of sulphur dioxide

Setting the rate of flow of sulphur dioxide

1. Find the mass of the sulphur dioxide canister (M_1g).
2. Set up the apparatus in the fume cupboard, as shown in Figure B4.1. Switch the fume cupboard on.
3. Open the valve on the gas canister very slowly. When bubbles appear in the measuring cylinder, start the stop clock. Adjust the valve so that 100 ml of gas bubbles into the measuring cylinder during a period of between 10 and 20 seconds.
4. Without touching the valve, break the connection between the canister and the apparatus.
5. After 60 seconds take a reading of the concentration of sulphur dioxide in the exhaust gas emitted by the fume cupboard with the gas detection kit with a suitable tube.[3] (A slight smell of sulphur dioxide should be ignored but, if the exhaust gas causes breathing difficulties, stop the test.)
6. Close the valve on the gas canister and stop the clock, noting the time of the run (t seconds).
7. Find the mass of the sulphur dioxide canister (M_2g).

Calculation

Rate of release of sulphur dioxide

$$= \frac{(M_1 - M_2) \times 375}{t} \text{ cm}^3 \text{ s}^{-1}.$$

Now check your results with Table B4.1.

Filter efficiency

Compare your value of the rate with the concentration of sulphur dioxide in the exhaust gas. If the concentration of sulphur dioxide is greater than the value in the table then a new filter is required. This assumes that the efficiency of the filter has fallen to 98% for sulphur dioxide; at this level the fume cupboard will still not emit a dangerous level of gas in a normal sized laboratory which is well ventilated; at two air changes per hour or more.

Table B4.1
Safe filter efficiencies for sulphur dioxide

Rate of sulphur dioxide released ($cm^3 s^{-1}$)	Maximum permitted concentration of sulphur dioxide in the exhaust gas (ppm)
5	1
10	2
15	3
20	4
25	5
30	6

B4.2 Method using burning sulphur

This method can be used if sulphur dioxide in a small cartridge or cylinder, which can be weighed, cannot be obtained at a reasonable price. The rate of release of sulphur dioxide is calculated by weighing the vessel containing the sulphur before and after it has burned for a measured time. It is satisfactory provided a) the Bunsen burner is turned off once the burning of sulphur starts and b) the apparatus is sited as far forward in the fume cupboard as possible, as shown in Figure B4.2, to obtain complete combustion.[4]

The items required are powdered roll sulphur (150-200g), a flat-bottom porcelain evaporating basin,[5] a gas detection kit, a balance weighing to 0.1g or less, a stop clock, a Bunsen burner, two gauze squares both with ceramic circular centres, a tripod, a heat-proof mat and a ruler. Wear eye protection. Sulphur dioxide is a toxic gas, so do not breathe it in.

References

[3] Equipment can be obtained from either Detectawl Ltd, 2 Cochran Close, Crownhill, Milton Keynes, MK8 0AJ (Gastec) or from Draeger Ltd, Ullswater Close, Kitty Brewster Industrial Estate, Blyth, NE24 4RG.

[4] SSERC earlier developed a similar method. See *'Monitoring of recirculatory filters'*, Science & Technology Bulletin (177), June 1993 from SSERC; see address on page 56.

[5] Available from Griffin and George, Cat No BHW-300-010 V (63mm diameter x 13mm) or Cat No BHW-300-030 P (80mm diameter x 20mm) or Philip Harris, Cat No R25900/5 (75mm diameter x 20mm) or Cat No R25902/9 (93mm diameter x 25mm).

1. Powder the roll sulphur in a mortar with a pestle.
2. Fill a flat-bottom porcelain evaporating basin with the sulphur so that it is level with the rim.
3. Weigh the porcelain basin, the sulphur and one of the gauzes (M_1g).
4. Set up the Bunsen burner, tripod, the other gauze and the evaporating basin on a heat-proof mat so that the centre of the basin is 5cm inside the upper rim of the aperture. (Figure B4.2) (This places the sulphur in the maximum incoming draught and encourages complete combustion.)
5. Switch on the fume cupboard.
6. Light the Bunsen burner with the gas tap half-open and the collar open enough so that the flame is non-luminous. (The incoming draught may require you to place the burner a little more forward than under the centre of the basin (Figure B4.2.)).
7. The sulphur melts slowly to a pale amber liquid. **Extreme care is now required not to knock the tripod base with your hands or the Bunsen burner; molten sulphur can cause severe burns.** Remove the Bunsen burner from under the gauze and adjust the collar so that it is half-open. Place it back under the gauze very carefully. (The liquid will quickly darken. Changes in the appearance of the liquid surface indicate that burning is about to start. Sulphur catches light with a blue flame.)
8. Start the stop-clock when half of the surface of sulphur has caught alight. Immediately turn off the Bunsen burner at the gas tap. (The flame above the sulphur has two coloured areas, the inner brown flame of incomplete combustion and the outer blue flame of complete combustion. Extinguishing the Bunsen burner causes the area of brown flame to diminish leaving the blue flame.)

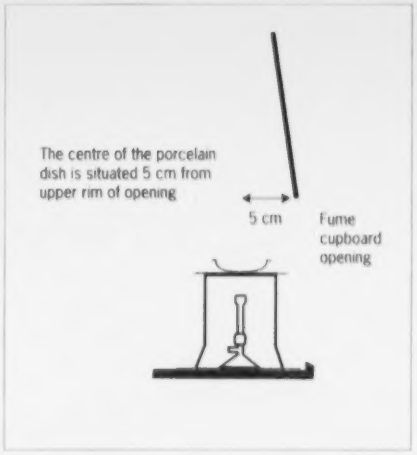


Figure B4.2
Burning sulphur method: position of the evaporating basin

9. After 60 seconds, take a reading of the concentration of the sulphur dioxide being emitted through the exhaust with a gas detection kit.[6] A slight smell of sulphur dioxide should be ignored but, if the exhaust gas causes breathing difficulties, stop the test.
10. Place the other gauze (which was used in the weighing) on top of the basin and stop the clock, noting the time (t seconds). (The gauze puts out the flame but some sulphur condenses onto it, which is why it should be included in the weighing.)
11. When the sulphur has cooled down for about 20 minutes and solidified, reweigh the basin, the remaining sulphur and the gauze (M_2g).

The sulphur and dish may be kept and used the next time the test is carried out. A little more powdered roll sulphur may need to be added to make up for any lost in the previous burning.

Calculation

Rate of release of sulphur dioxide

$$= \frac{(M_1 - M_2) \times 750}{t} \text{ cm}^3\text{s}^{-1}.$$

Now check your results with Table B4.1.

Reference

[6] Equipment can be obtained from either Detectawl Ltd, 2 Cochran Close, Crownhill, Milton Keynes, MK8 0AJ (Gastec) or from Draeger Ltd, Ullswater Close, Kitty Brewster Industrial Estate, Blyth, NE24 4RG.

Reference

[7] Use either a Gastec Precision Pump with a trichloroethene tube 132L (low range 1 - 50 ppm) or a Draeger Gas Detection Pump with a trichloroethene tube 2/a (2 - 200 ppm). Equipment can be obtained from either Detectawl Ltd, 2 Cochran Close, Crownhill, Milton Keynes, MK8 0AJ (Gastec) or from Draeger Ltd, Ullswater Close, Kitty Brewster Industrial Estate, Blyth, NE24 4RG.

B4.3 Test for saturation by organic gases

Method using trichloroethene

Since in normal school use a filter is most likely to saturate with acid gases long before it saturates with organic vapours, this test has only a limited use; it is an alternative test for seeing whether a filter is properly seated, ie, that the seals round it are effective. The rate of release of trichloroethene vapour is calculated by weighing a vessel containing trichloroethene liquid before and after it has been boiled for a measured time.

Items required are a gas detection kit[7] trichloroethene (trichloroethene, is a Class 3 carcinogen: ie, it possibly has carcinogenic effects but there is inadequate evidence for a satisfactory assessment although some evidence from animal studies. HARMFUL.), anti-bumping granules, a balance weighing to 0.1g or less, a stop clock, a 100ml conical flask with a bung, about 25ml of cold water in a 250ml beaker, a Bunsen burner, tripod and gauze square. (A hot plate is a suitable alternative.)

1. Pour about 25 ml of trichloroethene into the conical flask, add a few antibumping granules, attach the bung and find the overall mass (M_1g).
2. Set up the Bunsen burner, tripod and gauze in the fume cupboard and light the gas. Switch on the fume cupboard, remove the bung from the flask and place the flask on the gauze.
3. As the trichloroethene begins to boil, the vapour condenses on the cooler parts of the flask forming a boundary line. When the boundary reaches the top of the flask, start the stop clock.
4. After 60 seconds take a reading of the concentration of trichloroethene in the exhaust gas emitted by the fume cupboard, using a gas detection kit with a suitable tube.
5. Turn off the Bunsen burner. Place the conical flask (care necessary as the glass is hot), into the beaker of cold water in the fume cupboard and replace the bung. Stop the clock, noting the time of the run (t seconds).
6. After 3 minutes, remove the flask from the water, dry the outside of the conical flask and find the mass of the flask, contents and bung (M_2 g).

Calculation

Rate of release of trichloroethene vapour $= \frac{(M_1 - M_2) \times 183}{t}$ $cm^3 s^{-1}$.

Now check your results with Table B4.2.

Filter efficiency

Compare your value of the rate with the concentration of trichloroethene vapour in the exhaust gas. If the concentration of trichloroethene vapour is greater than the value in Table B4.2 then the filter is not properly seated or a new filter is required. This assumes that the efficiency of the filter has dropped to 96% for organohalogens; at this level the fume cupboard will still not emit a dangerous level of any organic vapour a school is likely to use in a a normal sized laboratory which is well ventilated.

Disposal of filters

Saturated filters should be securely wrapped in two layers of polythene, ie, put inside two bin liners, sealed with parcel tape and placed in the refuse.

Table B4.2
Safe filter efficiencies for trichloroethene

Rate of trichoroethene vapour released ($cm^3 s^{-1}$)	Maximum permitted concentration of trichoroethene vapour in the exhaust gas (ppm)
10	4
15	6
20	9
25	11
30	13
35	16
40	18
45	20

Appendix B5: Record form for 14-monthly face velocity, filter saturation and visual examination

Employer .....

Fume Cupboard 14-monthly Examination Record

School/College: .....

Location of fume cupboard: .....

Air flow meter used: .....

a	b	c
d	e	f
g	h	i

Date	Readings in the 9 cells at maximum aperture (ms^{-1})									Average (ms^{-1})	Drop >10% from last year?*	Do any filters pass saturation test?	Does a test show flow inwards?	Any deterioration or damage? Fail if face velocity < $0.3ms^{-1}$	Initials of tester
	a	b	c	d	e	f	g	h	i						

*If a drop of more than 10% is found the system should be investigated until the cause is clear. If it results in the minimum face velocity falling below $0.3ms^{-1}$ then the fume cupboard should be failed.

Appendix C: Commissioning schedules

Those wanting to purchase and to have installed a fume cupboard in accordance with the recommendations of this bulletin are advised to include in the contract, clauses based on the statements in schedules C1 – C4. The bulletin allows flexibility so that, within the recommendations, there are several features which are subject to agreement between the customer and the supplier or installer. Such agreement should be made prior to the awarding of the contract.

At the commissioning of the fume cupboard system, the customer may wish the manufacturer and installer to confirm that they have complied with these clauses. The customer will wish to check this compliance and may be expected by the contractors to sign a statement that the system meets the stipulations of the contract.

The supplier of the fume cupboard and the installer may be different contractors making it more difficult to achieve a satisfactory final result. Because of the different arrangements which can be made, it is not possible to divide the statements precisely into those for the supplier and those for the installer; the indication in the fourth column can be only approximate.

BEST COPY AVAILABLE

Schedule C1: Statements for all fume cupboards

(S= supplier;
I = installer)

Reference Sections	Feature	Requirement	S or I	Contractor's Statement
4.3	Working aperture	What is the height of the working aperture? (It should be at least 400mm for a ducted fume cupboard and 360mm for a filter fume cupboard).	S	..... mm
		Is there a maximum stop?	S	
		How is it released?	S	
		Is there a minimum stop ensuring a gap of at least 50mm?	S	
4.4 - 4.9	Face velocity	What is the minimum face velocity at the full working aperture? (It should be at least 0.3ms^{-1}.) Append a table showing the nine measurements as in Appendix B2.	S/I	..... ms^{-1}
		What is the variation? (It should be less than ±30%.)	S/I	Upper .....% Lower .....%
		What type of air flow meter was used?	S/I	
		When was the meter last calibrated?	S/I	
		Were corrections applied from the calibration certificate?	S/I	
		What flow indicator, if any, is fitted to the fume cupboard?	S/I	
4.10 - 416	The sash	What is the support system?	S	
		Is it fail safe?	S	
4.17 - 4.20	Internal dimensions	Do these conform to recommendations?	S	
4.21 - 4.22	Duct exit position	Is it in the middle of the width?	S/I	
4.23 - 4.25	Bypass	Is one fitted?	S	
		What is the increase in average face velocity as the sash is lowered from 400 to 200mm?	S	
4.26 - 4.27	Baffle	Is one fitted? (It is not essential and may be omitted, particularly in demonstration-type fume cupboards.)	S	
4.28 - 4.30	Work surface	What is the material? Is the material in the list of those recommended?	S	
		Is it dished or does it have a lip?	S	
4.32	Glazing	What is it? Does the glazing material conform to recommendations?	S	
4.33 - 4.34	Maintained illuminance	Is it at least 300 lux?	S/I	
		Do light fittings prevent ingress of gases?	S	
4.35 - 4.49	Services	Do these conform to recommendations?	S/I	
4.72	Information	Is the information displayed on the fume cupboard complete and prominently displayed?	S/I	

Schedule C2: Statements for demonstration and mobile fume cupboards

(S= supplier; I = installer)

Reference Sections	Feature	Requirement	S or I	Contractor's Statement
4.32	Glazing	Is the fume cupboard glazed all round?	S	
4.35 - 4.49	Services	Do these meet recommendations and as agreed between the parties?	S/I	
4.50	Stability	How is this achieved? Does it meet recommendations?	S	
4.51 - 4.53	Ducting	Does this meet the recommendations?	I	
5.1 - 5.14	Siting	Position as agreed by the parties?	I	

Schedule C3: Statements for filter fume cupboards

(S= supplier; I = installer)

Reference Sections	Feature	Requirement	S or I	Contractor's Statement
4.58 - 4.68	Filter specification	Does the filter meet the requirements?	S	
		In particular, does it meet the efficiencies of Table 4.1?	S	
		Which independent organisation has type-tested this filter?	S	
		What means of testing for filter saturation is advised?	S	
4.72	Information	Is this complete and prominently displayed?	S	

Schedule C4: Statements for ducted fume cupboards

(S= supplier; I = installer)

Ref.	Feature	Requirement	S or I	Contractor's Statement
5.1 - 5.14	Siting	Is this as agreed between the parties, after discussion bearing Section 5 in mind?	I	
6.6 - 6.8	Individual or shared extraction?	Is this as agreed between the parties?	I	
6.9 - 6.11	Siting of the fan?	Is this as agreed between the parties?	I	
6.12 - 6.15	Damper	Is a damper fitted?	I	
		Is the damper control fitted with a locking device?	I	
6.16 - 6.19	Make-up air	Outline the provision for make-up air in the laboratory.	I	
6.20 - 6.22	Noise	What is the noise level at the prescribed position? Is it less than 65dBA?	I	
6.23 - 6.27	Ductwork	Does this conform to recommendations and as agreed between the parties?	I	
6.28 - 6.38	The fan	Are all parts in contact with gases acid proof? Is the fan motor well sealed from the gases?	I	
		Is it a centrifugal fan?	I	
		If not, give reason and whether agreed between parties.	I	
		Are other recommendations met?	I	
6.39 - 6.45	Discharge height	Are fumes discharged at a minimum of 1m above the highest point of the building?	I	
	Stack	Is discharge vertical and greater than $5ms^{-1}$?	I	
		Is the location as agreed between parties?	I	
		Are other recommendations met?	I	

Appendix D: Chemicals and reactions contained by Building Bulletin 88 fume cupboards

Fume cupboards should not be used to store chemicals.This can increase hazards if a fire or an explosion occurs or if an item of equipment is dropped or knocked over. In addition, they are not secure; there have been cases in which bromine has been stolen from a fume cupboard in a laboratory. Clearly, unsealed containers of fuming substances should not be left in a mobile fume cupboard being moved from one site to another, nor should there be any hazardous chemicals, etc, in a mobile fume cupboard left unattended in a corridor, waiting to be moved into a room. Detailed guidance on storage of chemicals is given elsewhere.[1]

Appendix D1: Substances which can be released

The following is a list of substances which, in the quantities usual in school experiments, can be released safely in a fume cupboard meeting the recommendations of this bulletin. This claim is based on containment tests.[2]

Absence from the list does not necessarily imply that the gas or vapour is too toxic to be handled in such a fume cupboard or can be handled safely in the open laboratory.

Inclusion in the list does not necessarily imply that the gas or vapour cannot be handled safely in the open laboratory if quantities are sufficiently small.

Inorganic

- aluminium chloride and bromide
- ammonia
- ammonium chloride fumes
- bromine
- carbon monoxide*
- chlorine
- chromium(VI) dichloride dioxide (chromyl chloride)
- hydrochloric acid vapour
- hydrogen*
- hydrogen chloride
- hydrogen sulphide
- iodine
- iodine chlorides
- lead fumes
- lead bromide fumes
- mercury and its compounds
- nitric acid vapour
- nitrogen oxides
- phosphine
- phosphorus (white)
- phosphorus chlorides and bromides
- phosphorus oxides
- silicon tetrachloride
- sulphur chlorides
- sulphur dioxide
- thionyl chloride
- tin(IV) chloride
- titanium tetrachloride
- zinc chloride fumes

Organic

- acid amides
- acid anhydrides
- acid chlorides
- alcohols
- aldehydes
- aliphatic amines and their salts
- aliphatic hydrocarbons*
- aromatic amines and their salts
- aromatic hydrocarbons
- aromatic nitro compounds
- carboxylic acids
- esters
- ethers
- ketones
- nitriles
- organohalogens
- phenols
- pyridine

Dust, etc

- dyes
- enzymes
- smoke

* Hydrogen, carbon monoxide and methane will not be absorbed by filters because of their low molecular mass.

References

[1] Hazcards, 1995, available to members of CLEAPSS.

CLEAPSS Laboratory Handbook, 1989.

CLEAPSS Guide L148a Chemical Storage.

See CLEAPSS address in further information on page 56.

[2] The investigations are reported in 'School Fume Cupboards', J R Crellin, Education in Chemistry 21 (6), November 1984, pp 185-8.

Appendix D2: Procedures which can be carried out

Reference
[1] *Safety in Science Education*, DfEE, HMSO, 1996, ISBN 0 11 270915 X, £14.95.
Hazcards, 1995, available to members of CLEAPSS. See address on page 56.

Various texts[1] recommend that these procedures be carried out in fume cupboards. Absence from the list does not necessarily imply that the procedure is too hazardous to be handled in a fume cupboard meeting the recommendations of this bulletin or can be handled safely in the open laboratory.

Inclusion in the list does not necessarily imply that the procedure cannot be handled safely in the open laboratory if quantities are sufficiently small.

Procedure	Bunsen required?	Drain required?	KS3	KS4	Years 12 and 13
Alkali metals reacting with water		✓	✓	✓	✓
Aluminium chloride (anhydrous) preparation	✓	✓			✓
Aluminium reacting with iodine			✓	✓	✓
Aluminium with mercury salt solutions				✓	✓
Ammonia: catalytic oxidation	✓			✓	✓
Ammonia: dispensing of '880'				✓	✓
Ammonia preparation	✓	✓		✓	✓
Ammonia reacting with hydrogen chloride			✓	✓	✓
Ammonium chloride heating	✓		✓	✓	✓
Ammonium dichromate decomposition (volcano experiment)	✓		✓	✓	✓
Aromatic amine preparation	✓	✓			✓
Benzoyl chloride: dispensing and reactions	✓	✓			✓
Bromination of alkenes (eg cyclohexene, styrene)		✓		✓	✓
Bromine diffusion experiments		✓	✓	✓	✓
Bromine/hydrocarbon reactions		✓		✓	✓
Bromine reacting with iron	✓		✓	✓	✓
Burning plastics	✓			✓	✓
Butylamine reactions to illustrate reactions of aliphatic amines		✓			✓
Cannizzaro's reaction using benzaldehyde					✓
Carbon disulphide handling				✓	✓
Carbon monoxide preparation (Not in a filter fume cupboard.)	✓	✓		✓	✓
Carbon monoxide reducing metal oxides	✓			✓	✓
Cellulose dissolving in strong ammonia solution		✓		✓	✓
Chlorine preparation		✓	✓	✓	✓
Chlorine reacting with metals		✓	✓	✓	✓
Cholesteryl benzoate preparation using pyridine as a solvent	✓				✓
Chromatography using organic solvents			✓	✓	✓
Chromyl chloride preparation	✓				✓
Contact process demonstration	✓			✓	✓
Copper pyrites heating	✓		✓	✓	✓
1,4 - dichlorobenzene to pre-treat root tips to arrest metaphase	✓			✓	✓

Procedure	Bunsen required?	Drain required?	KS3	KS4	Years 12 and 13
Dichloromethane extractions (eg caffeine from tea)	✓				✓
Dissolving alloys in aqua regia for concentrated nitric acid or analysis		✓		✓	✓
Electrolysis of molten lead bromide	✓			✓	✓
Electrolysis of molten sodium hydroxide	✓			✓	✓
Electrolysis of molten zinc chloride	✓			✓	✓
Ethanal: reactions and dispensing					✓
Ethanoic acid: reactions and dispensing	✓				✓
Ethanoic anhydride: reactions and dispensing		✓			✓
Ethanoyl chloride: reactions and dispensing		✓			✓
Fountain experiments with ammonia, hydrogen chloride or sulphur dioxide				✓	✓
Friedel-Craft reactions	✓	✓			✓
Galena (lead sulphide) heating	✓		✓	✓	✓
Halides with concentrated sulphuric acid	✓	✓			✓
Halogenoalkane solvent dispensing		✓		✓	✓
Harlow's solution for macerating woody tissue	✓				✓
Hoffman bromination reaction	✓				✓
Hydrocarbon solvent dispensing		✓		✓	✓
Hydrogen burning in chlorine	✓	✓	✓	✓	✓
Hydrogen chloride dissolving in methylbenzene		✓		✓	✓
Hydrogen chloride gas preparation	✓	✓		✓	✓
Hydrogen sulphide: preparation and reactions	✓				✓
Iodine: action of heat (sublimation)	✓		✓	✓	✓
Iodine reactions with metals other than aluminium	✓		✓	✓	✓
Iron(III) chloride preparation	✓				✓
Mercuric solutions dispensing				✓	✓
Mercury heating to form oxide	✓		✓	✓	✓
Mercury oxide heating	✓		✓	✓	✓
Mercury reacting with iodine	✓		✓	✓	✓
Mercury used as an electrical contact			✓	✓	✓
Methanal for use as a preservative, fixative or to kill microbes			✓	✓	✓
Methanol oxidation using a copper spiral	✓			✓	✓
Methyl methacrylate polymerisation	✓			✓	✓
Naphthalene cooling curve demonstration	✓		✓	✓	✓
Nickel carbonate decomposition	✓				✓
Ninhydrin spraying of chromatograms		✓			✓
Nitric acid preparation	✓	✓		✓	✓

BEST COPY AVAILABLE

Appendix D2: Procedures which can be carried out

Procedure	Bunsen required?	Drain required?	KS3	KS4	Years 12 and 13
Nitric acid reacting with copper		✓	✓	✓	✓
Nitric acid reaction with sawdust	✓			✓	✓
Nitrogen dioxide preparation	✓	✓		✓	✓
Electrolysis of molten lead bromide	✓			✓	✓
Nitrogen monoxide preparation	✓	✓		✓	✓
Organic acid anhydride preparation	✓	✓			✓
Organic acid chloride preparation	✓	✓			✓
Organic solvent warming	(✓)			✓	✓
Perspex depolymerisation	✓			✓	✓
Phenol dispensing					✓
Phenol/methanal resin preparation	✓				✓
Phenylamine reactions illustrating aromatic amines		✓			✓
Phenylethene polymerisation	✓			✓	✓
Phosphine preparation	✓	✓			✓
Phosphorus allotropy	✓	✓			✓
Phosphorus burning	✓		✓	✓	✓
Phosphorus burning in chlorine	✓			✓	✓
Phosphorus chloride reactions		✓			✓
Silicon tetrachloride reactions		✓			✓
Sugar reacting with concentrated sulphuric acid			✓	✓	✓
Sulphide precipitations (using ammonium sulphide or hydrogen sulphide sol)		✓			✓
Sulphur burning	✓		✓	✓	✓
Sulphur dioxide handling			✓	✓	✓
Tetrachloromethane: dispensing and use					✓
Thermal decomposition of nitrates	✓			✓	✓
Thermal decomposition of potassium iodate	✓				✓
Thermite reaction	✓		✓	✓	✓
Tin(IV) chloride preparation	✓	✓			✓
Tin(IV) iodide preparation	✓				✓
Trichloromethane: dispensing and use				✓	✓
Urea/formaldehyde (methanal) resin preparation		✓		✓	✓
Zinc reacting with sulphur				✓	✓

Any procedures a technician is likely to carry out in supporting normal activities in school science can be carried out safely in a fume cupboard meeting Building Bulletin 88 specifications.

Appendix E: Exposure limits and calculation of gas levels in laboratories

With some procedures using certain chemicals, it is necessary to consider the likely build-up of hazardous gas levels in the air in order to decide whether to make use of a fume-cupboard or otherwise limit the exposure in the laboratory. The recommendations for fume cupboards in this bulletin are based on experimental work in which measurements were made of concentrations in the air resulting from the releases of gases and vapours from a number of operations such as pouring solvents and preparing gases such as chlorine. These operations were conducted in the open laboratory and in a fume cupboard of a certain standard and the concentrations obtained were compared to occupational exposure limits.[1]

This work led not only to the recommendations for fume cupboards given in this bulletin but also to the advice given in various safety texts[2] on quantities of reactants and on when fume cupboards are needed.

A science department using fume cupboards which meet the recommendations of this bulletin and using fume cupboards as recommended by standard safety texts, need not conduct its own risk assessments. However, it is instructive for both staff and pupils to attempt some assessments and the information and examples below are intended to aid them.

Appendix E1: Occupational exposure limits

There are two occupational exposure limits: **Maximum Exposure Limits (MELs) and Occupational Exposure Standards (OESs).** Airborne noxious substances are assigned one or the other, most being in the OES category. The distinction between the two categories refers to the evidence, often incomplete and difficult to interpret, on which these levels are based. They both refer to concentrations of substances in the air of a workplace and are usually expressed in parts per million (ppm) or milligrams per cubic metre (mg m^{-3}). They are normally stipulated for two reference periods.

MELs and OESs are updated periodically and a list is published annually.[3]

Maximum Exposure Limits

These, as the name implies, are the maximum permissible concentrations of airborne substances. For a MEL, there must be evidence that exposures which equal or exceed it can result in harm to health; therefore, it should never be exceeded and employers should ensure that exposure is kept as far below it as is reasonably practicable. As part of the COSHH Regulations[4] MELs have legal status.

Occupational Exposure Standards

These represent concentrations which, according to current evidence, will not injure employees exposed to them day after day. An exposure should not exceed an OES but, if it does, control will still be considered adequate if the employer knows why the OES has been exceeded and is taking steps to comply with it as soon as is reasonably practicable. To avoid exposures above an OES, it is prudent to reduce airborne concentrations to substantially below it. OESs have advisory, 'good practice' status.

Reference periods

Long-term exposure limits (8-hour TWA reference period) are limits relevant for daily work averaged over eight hours; 'TWA' means 'time-weighted average'.

Short-term exposure limits (STELs) (15-minute reference period) are limits relevant for an occasional exposure.

Which reference period for school science?

Because most science activities in education last for only a short time and are seldom repeated by the same individual, short-term exposure limits are usually more relevant than long-term limits. However, the limits are devised for adults and younger persons may be more susceptible to toxic effects; exposures should be even lower than those considered safe for adults.

References

[1] The investigations are reported in *'School Fume Cupboards'*, J R Crellin, Education in Chemistry 21 (6), November 1984, pp 185-8.

[2] *Hazcards*, 1995, available to memebers of CLEAPSS. See address on page 56.

[3] These are published annually in *Guidance Note EH40 Occupational Exposure Limits*, HSE Books. The ISBN changes annually. Available from HSE Books, PO Box 1999, Sudbury, Suffolk, CO10 6FS.

[4] The General COSHH ACOP, Carcinogens ACOP and Biological Agents ACOP (one booklet), HSE, 1995, ISBN 0 7176 0819 0. Available from HSE Books, PO Box 1999, Sudbury, Suffolk, CO10 6FS.

Why schools need not calculate gas levels

As has just been stated, every endeavour should be made to reduce actual levels of vapours and gases in the air to values well below the limits. School staff are not in a position to measure these levels nor is it normally necessary to do so. Estimates and measurements have been made in compiling the published advice recommended as the basis of risk assessments[5] and the recommendations in this Building Bulletin.

In some cases the sense of smell is a useful warning indicator although this should be treated with caution: the nose is a very sensitive indicator. On the other hand, not all chemicals can be smelt at their limit levels.

Reference

[5] The investigations are reported in 'School Fume Cupboards', J R Crellin, *Education in Chemistry 21 (6)*, November 1984, pp 185-8.

Appendix E2: Calculations of exposure levels

Purpose of calculations

While it is not necessary to do this, it is of educational value both for staff and pupils to know how values can be calculated. Often a simple calculation will demonstrate that a level is not likely to be exceeded.

Gas levels can sometimes be estimated using the formula[1]:

$$C = \frac{RK\,(1 - e^{-nt})}{Vn}$$

Where:

- C concentration in air (ppm)
- R release rate (cm^3s^{-1})
- K factor to allow for uneven distribution
- V volume of room (m^3)
- n rate of air change (s^{-1})
- t duration of release (s)

For some purposes the simpler formula:

$$C = \frac{RK}{Vn}$$

is adequate; this gives a higher estimate because it applies to the case where the release of gas is continuous.

Obviously some of these values are difficult to estimate and the choice of a value for K is very subjective. For the usual school laboratory the following values can be taken:

R will have to be estimated. There are various ways of doing this; an example is given below.

K = 10 (corresponding to poor distribution conditions)[2]

V = 200 m^3

n = 2 air changes per hour for a naturally ventilated laboratory which is well ventilated:

$$n = \frac{2}{60 \times 60} = 5.56 \times 10^{-4}\ s^{-1}$$

t depends upon the particular circumstances.

Many procedures have been investigated at the CLEAPSS School Science Service in the past few years. Only one example is given here.

Example calculation to estimate the vapour level on heating lead nitrate

If 2g is heated in a test-tube on an open bench, taking about two minutes to complete the reaction:

$$2Pb(NO_3)_2 \rightarrow PbO + 4NO_2 + O_2$$

Molecular weight, M_r = 331

$\frac{2}{331}$ moles lead nitrate will produce

$\frac{4}{331}$ moles of nitrogen dioxide.

This has a volume of $\frac{4 \times 24}{331}$ litre,

giving a release rate of 0.29 litres in 2 minutes or $\frac{0.29 \times 100}{2 \times 60}$ cm^3s^{-1}.

Thus R is about 0.24 cm^3s^{-1} and the formula for concentration becomes:

$$C = \left[0.24 \times 10 \times (1 - e^{-5.56 \times 10^{-4} \times 120})\right] / 0.1$$

= 1.6 ppm: which is below the STEL of 5 ppm.

Conclusion

This suggests that this experiment may be done at this scale on the open bench but, if done on a class scale, the STEL will be exceeded.

References

[1] From *Dangerous Properties of Industrial Materials*, Sax, N I, 1979, Van Nostrand, ISBN 0442 27373 8.

[2] In a well ventilated laboratory with an air change rate of 2 air changes per hour and a fume cupboard in use K = 2, see page 14, Table 4.1.

Glossary

Nouns in bold appear elsewhere in this glossary.

absorbed	When a **gas** or liquid is taken up within a filter or within the body of a solid.
acid gas	The halogens and halides, the oxides of nitrogen and sulphur and vapours from the acids commonly used in school science.
adsorbed	When a **gas** or liquid is taken up on the surface of a solid.
air flow meter	A meter which measures the velocity of a current of air and so can be used for measuring **face velocity.**
anemometer	In this Building Bulletin, it is used to mean the same as **air flow meter.**
baffle	A panel, often in two parts, mounted at the back of a fume cupboard whose purpose is to minimise variation. (Figures 4.1 and 4.2)
bollard	A pedestal unit in a laboratory on which are mounted gas and electricity outlets for equipment on movable benches which are grouped near it; it often contains a sink with water outlets above.
bottle trap	A small trap for solid materials fitted in the drainage system beneath a sink or drip cup.
BS	British Standard.
bypass	Also called a **secondary air inlet.** It provides an entry for air into a fume cupboard, other than the working aperture, and its purpose is to keep the volume air flow and **face velocity** constant as the position of the **sash** is changed. (Figure 4.1)
containment	The ability of a fume cupboard to prevent a **gas** released inside it from escaping through the working aperture.
damper	A device fitted into the extract duct to control the **volume air flow** by varying the resistance to airflow.
desorption	The process of re-emission of a **gas** previously **absorbed.**
drip cup	A very small sink beneath a tap, intended to catch the water from the tap and sufficiently large to receive the contents of test tubes, small beakers etc.
face velocity	This is the velocity of air through the working aperture, measured in the plane of the **sash.**
fumes	The mixture of air and contaminants (hazardous gases and vapours, aerosols, smoke, etc.) within or discharged from a fume cupboard.
GCE A-level	Advanced Level of the General Certificate of Education. (The Ordinary Level has been replaced by the GCSE.) The majority of students taking it are about 18 years old.
GCSE	General Certificate of Secondary Education, taken by pupils after Key Stage 4 of the National Curriculum, when the majority of pupils taking it are about 16 years old.
GNVQ	General National Vocational Qualification.
gas	In this bulletin, the term 'gas' will often include the term **'vapour'**. Strictly, 'vapour' is the correct term for the gaseous phase of a substance when it is below its critical temperature; ie, it can be liquified by pressure alone.
detection kit	It consists of a pump which is operated manually to draw a precise and measured quantity of air through a **gas** detection tube, a disposable tube, sealed until its ends are broken just before use. A different tube is usually required for each **gas.** The length of the colour change within the tube indicates the concentration of the **gas** tested.
HSC	Health & Safety Commission.
HSE	Health & Safety Executive.

Make-up air	The air entering a room to replace that extracted by the fume cupboard and by any other devices also extracting air.
MEL	Maximum Exposure Limit. (Appendix E1).
negative pressure	A pressure, eg, inside a duct, which is below atmospheric pressure.
OES	Occupational Exposure Standard. (Appendix E1).
organic	Organic compounds contain carbon atoms, usually linked to other carbon atoms.
ppm	Parts per million, a measure of concentration.
PVC	Polyvinyl chloride, a plastic.
RCD	Residual Current Device. Intended to protect users of electrical equipment, it will break a circuit if a current flows from its line or neutral conductors to earth.
risk assessment	A systematic consideration of any activity in which there is a hazard, followed by decisions on the substances, equipment and procedures used and on the restrictions and precautions needed to make the risk acceptably low.
rpm	Revolutions per minute.
sash	The transparent screen between the inside of a fume cupboard and the user. It can usually be raised and lowered.
plane of the	The plane of the sash is the plane through the centre of the sash itself, ie, not through the handle etc.
secondary air inlet	See **bypass** above.
spigot joint	Used to join ducting. One section of ducting is sealed inside a section of slightly greater diameter.
STEL	Short Term Exposure Limit. (Appendix E1).
thermal overload device	Prevents a device powered by electricity from over-heating; eg, an electric motor when starting.
vapour	See **gas**.

Further information

Detailed information on many points is given in the references in each section. However, there are two organisations which review models of fume cupboards suitable for schools and which can give, to their subscribers, advice and information on many of the points in this Building Bulletin.

The CLEAPSS School Science Service
Brunel University
Uxbridge UB8 3PH
Tel: 01895 251 496. Fax: 01895 814 372.

95% of schools in England, Wales and Northern Ireland are members through education authority subscriptions. Many independent schools, GM schools and independent colleges are also subscribers.

The Scottish Schools Equipment Research Centre (SSERC)
24 Bernard Terrace
Edinburgh EH8 9NX
Tel: 0131 668 4421. Fax: 0131 667 9344.

All education authority schools in Scotland are members through education authority subscriptions. Many independent schools, GM schools and independent colleges are also subscribers.

There is also a trade association to which many manufactures of fume cupboards belong.

UK Fume Cupboard Association
Owles Hall
Buntingford, Herts SG9 9PL
Tel: 01763 271209. Fax: 01763 273255.
E-mail: fca@owles.co.uk

The Stationery Office

Published by The Stationery Office and available from:

The Publications Centre
(mail, telephone and fax orders only)
PO Box 276, London SW8 5DT
General enquiries 0171 873 0011
Telephone orders 0171 873 9090
Fax orders 0171 873 8200

The Stationery Office Bookshops
59–60 Holborn Viaduct, London EC1A 2FD
temporary until mid 1998
(counter service and fax orders only)
Fax 0171 831 1326
68–69 Bull Street, Birmingham B4 6AD
0121 236 9696 Fax 0121 236 9699
33 Wine Street, Bristol BS1 2BQ
0117 9264306 Fax 0117 9294515
9–21 Princess Street, Manchester M60 8AS
0161 834 7201 Fax 0161 833 0634
16 Arthur Street, Belfast BT1 4GD
01232 238451 Fax 01232 235401
The Stationery Office Oriel Bookshop
The Friary, Cardiff CF1 4AA
01222 395548 Fax 01222 384347
71 Lothian Road, Edinburgh EH3 9AZ
(counter service only)

Customers in Scotland may
mail, telephone or fax their orders to:
Scottish Publications Sales
South Gyle Crescent, Edinburgh EH12 9EB
0131 228 4181 Fax 0131 622 7017

The Stationery Office's Accredited Agents
(see Yellow Pages)

and through good booksellers

£14.95

BEST COPY AVAILABLE

ISBN 0-11-270271-1

9 780112 710271 >